DOCUMENT RESUME

ED 325 106 IR 014 709

AUTHOR	Franklin, Sharon, Ed.; Strudler, Neal, Ed.
TITLE	Computer-Integrated Instruction Inservice Notebook: Secondary School Mathematics.
INSTITUTION	International Council for Computers in Education, Eugene, Oreg.
SPONS AGENCY	National Science Foundation, Washington, D.C.
REPORT NO	ISBN-0-924667-55-9
PUB DATE	88
CONTRACT	TEI-8550588
NOTE	310p.; For related documents, see IR 014 708-711. The two Macintash 800 diskettes that accompanying the notebook are not included in this document.
AVAILABLE FROM	International Council for Computers in Education, 1787 Agate Street, Eugene, OR 97403 (1-4 copies, $40.00 each prepaid).
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052) -- Guides - Non-Classroom Use (055) -- Book/Product Reviews (072)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	*Computer Assisted Instruction; *Computer Literacy; Databases; *Inservice Teacher Education; Mathematics Instruction; Postsecondary Education; Problem Solving; Secondary Education; *Secondary School Mathematics; *Secondary School Teachers; Spreadsheets; *Teaching Methods

ABSTRACT

The purpose of this notebook is to assist educators who are designing and implementing inservice education programs to facilitate the effective use of computer integrated instruction (CII) in schools. The book is divided into the following five sections: (1) Effective Inservice (a brief summary of inservice literature focused on inservice dimensions and design principles); (2) Background Information (an overview of computers in education and a discussion of the roles of computers in problem solving); (3) Initiating/Planning an Inservice (suggestions for preliminary planning and activities and a sample timeline for those activities); (4) An Eight-Session Mathematics Inservice (2-hour sessions on graphing to represent data, graphing equations, spreadsheets, problem solving, introduction to database software, geometry and visualization, inverted curriculum, and project reports and closure); and (5) Instruments and Evaluation (a variety of instruments for needs assessment, formative evaluation, and summative evaluation). Each 2-hour mathematics inservice session contains some or all of the following: narrative overview, script (topics, objectives, materials, activities), timeline, handouts, and readings. References are listed in the first three sections and a software bibliography is included in the fourth section. (DB)

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U.S. DEPARTMENT OF EDUCATION

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- Chairman of the Association for Computing Machinery's Elementary and Secondary School Subcommittee, 1978-1982.
- Founder, International Council for Computers in Education, 1979.
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Editors: Sharon Franklin, Neal Strudler
Cover Design: Percy Franklin
Production: Sue Gorecki

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ISBN 0-924667-55-9
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COMPUTER-INTEGRATED INSTRUCTION INSERVICE NOTEBOOK: SECONDARY SCHOOL MATHEMATICS[*]

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[*] The research and development for this Notebook was funded during 1985 - 1988 by the National Science Foundation grant TEI 8550588.

[**] Not all staff members worked specifically on the mathematics inservices. A number of volunteers also contributed to this project.

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- Narrative overview
- Script
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PREFACE

The purpose of this notebook is to assist educators who are designing and implementing inservice education programs to facilitate the effective use of Computer-Integrated Instruction (CII) in schools. CII involves the use of the computer as a problem solving tool. CII includes the use of applications such as databases, graphics, spreadsheets, telecommunications, and word processors; these are generic applications in the sense that they can be used in many different subject areas and grade levels. CII also includes use of special purpose software designed to help solve the problems occurring in specific courses or disciplines.

This Notebook was prepared by the staff of NSF Project TEI 8550588, which received three years of funding beginning September 1985. It is one of four notebooks to be prepared that include:

- CI^3 Notebook for Elementary School
- CI^3 Notebook for Secondary School Mathematics
- CI^3 Notebook for Secondary School Science
- CI^3 Notebook for Secondary School Social Science

The problem addressed by this NSF Research and Development Project is the disparity between the overall capabilities and potentials of CII and the current implementation levels of CII in our schools. There is strong support from computer-knowledgeable educational leaders for increased use of CII.

Growth in appropriate use of CII depends on schools having:

1. Access to appropriate hardware.
2. Access to appropriate software.
3. Access to appropriate curriculum and instructional support materials.
4. Appropriately trained teachers and school administrators who support increased use of CII.

The cost of computer hardware continues to decline even as its capabilities continue to increase. The amount of computer hardware available for instructional purposes is now sufficient to have a significant impact on schools. Moreover, hardware availability is continues to grow very rapidly. This project assumes that the problem of hardware access will gradually diminish; thus, this project does not focus on the hardware problem.

The quantity of educational software is continuing to grow, while the average quality continues to improve. A 1986 estimate suggested that there were about 10,000 educationally oriented, software programs for microcomputers commercially available. *The Educational Software Selector*, published by EPIE, lists nearly 8,000 titles. The amount and quality of CII software now available is adequate to support extensive use of CII in schools and to have a major impact on school curriculum. The educational market is large enough to support a viable, competitive industry with many companies participating.

This project does not focus on the overall problem of educational software. However, each Notebook contains information about a number of pieces of educational software. To the extent possible, the focus is on currently available generic CII software. In cases where more specific pieces of CII software are discussed, they were selected because they are readily available, and are apt to remain so for some years to come, and because they fit the specific instructional needs of the authors of these notebooks.

Instructional support materials include textbooks, workbooks, and reference materials; films, filmstrips, and video tapes; and course goals, course outlines, and teacher support materials. Although there is a substantial amount of instructional support material for learning/teaching about computers (teaching computer literacy, computer programming, and computer science), the amount of instructional support materials for CII is still quite limited. This project includes the development of a modest amount of CII teacher support materials; a number of sample lesson plans have been developed and are included in the notebooks, for example.

It is not, however, a major goal of this project to develop CII instructional support materials.

The NSF Research and Development project focuses on the development of effective methods for the inservice education of educators interested in CII. The materials contained in the notebooks are intended for computer education leaders who are designing and implementing CII inservice education workshops and courses. Each notebook contains a detailed outline of an eight-session workshop along with support materials. A number of "Copy Me" pages are included for dissemination in an inservice workshop or course.

It is recognized that designers and deliverers of inservice education vary widely in their experience, computer background, and academic area of specialization. With this in mind, two general methods are envisioned for using the materials in these notebooks. First, an inservice provider might rely heavily on a particular notebook, following it closely in giving a sequence of workshops or a course. Second, an inservice provider might use these notebook materials to get ideas and to serve as resources in designing and presenting CII instruction to educators. In either case it is expected that the inservice provider will benefit from use of the notebook materials and will learn some new ideas about effective inservice and CII.

This Notebook presents a particular philosophy of inservice education. It is a process-oriented philosophy, as distinguished from a content oriented philosophy. Thus, an inservice education program based on this Notebook will look quite different from the traditional computer-oriented inservices that have been widely presented in recent years. The resulting inservices are fun to lead and fun to participate in. They are an effective way to encourage the increased and appropriate use of computer-integrated instruction in schools.

How to Read and Use This Notebook

The purchaser of a single copy of this Notebook receives a print copy and a copy in *MacWrite* format on 800K Macintosh disks, and a single user site license.

The single user site license gives the one person who is designated as the "Primary User" of the site license the right to make copies of all of the materials in this book for classes he or she teaches. If the single user site license is purchased by a school or school district, the intent is that one person be designated as the "Primary User." If several people are to teach using this book, a multiuser site license should be purchased. The right to copy materials from the book does not transfer to participants in classes taught by the "Primary User."

Information about purchasing a multiuser site license can be obtained from the publisher, the International Council for Computers in Education, 1787 Agate Street, Eugene, Oregon 97403.

The disk copy is organized into folders, sub folders, and individual files in a systematic and relatively logical fashion. At the bottom of each page of the print copy there is information that will help you locate the appropriate file on disk. The typical footer consists of three parts:

Brief title of the book: CI^3 Notebook
File name: This is explained in more detail below.
Page number within the specific file: Each file is numbered sequentially starting at page 1.

The name of an individual file is two or three digits, separated by periods, and a brief title. You will notice that the name of the file you are currently reading is 0.4 Read and Use. The first digit of the sequence is a folder number. This file is in folder number 0. The second digit refers to a particular file within the folder unless there is a third digit. If there is a third digit, the second digit refers to a subfolder number, and the third digit to a file within that subfolder.

This Notebook contains a great deal of information to aid you in conducting an effective inservice for integrating computers into the curriculum. Most readers will want to skip around in the material, rather than reading it from cover to cover. This section is a guide to help such readers by presenting a brief summary of each section and how and when to use it.

Section 1: Effective Inservice

Substantial literature exists on effective inservice. This section of the Notebook contains a brief summary of the effective inservice literature followed by a discussion of the CI^3 model for the inservices designed for this NSF project. We recommend that you read all of this section.

Section 2: Background Information

The first part of this section is a general overview of computers in education. It might be used as a handout at an inservice for educators who have not had previous coursework or extended workshops on computer uses in schools.

The second part of this section discusses the roles of computers in problem solving. This is essential background information for all inservice presenters. It can also be used as a handout for workshop participants.

Section 3: Initiating/Planning an Inservice

This section offers a few suggestions to consider when beginning to plan an inservice. Novice inservice organizers will want to read this section.

Section 4: An Eight-Session Mathematics Inservice

The inservice described in this Notebook is eight sessions of two hours each. Although the information included can be presented in eight session, there is enough material for nearly 16 sessions if desired. We suggest that you carefully read through the materials for the first session to get the general idea of the information presented.

Session 1: Graphing to Represent Data. We chose to introduce graphics in the first session because all math teachers seem to experience personal success in using graphics packages. During this first session the participants will generate, use, and discuss line, bar, and circle graphs. The issue of when and how to use graphics software in math classes is discussed.

Session 2: Graphing Equations. Additional work on line, bar, and circle graphs. Use and discussion of software that graphs equations. Discussion of possible uses in the math curriculum and implications of integrating routine use of graphics software into the math curriculum.

Session 3: Spreadsheets. Introduction to spreadsheet software. Possible uses of spreadsheet software and similar software packages in the mathematics curriculum. (Note that adequate coverage of spreadsheets takes more than a single 2-hour session.)

Session 4: Problem Solving. Although problem solving is a theme that runs throughout the 8 weeks of the inservice, this session is specifically devoted to problem-solving software. We examine several pieces of software and discuss how they promote problem-solving skills.

Session 5: Database. Introduction to database software. Examination of possible uses of databases in the mathematics curriculum.

Session 6: Geometry and Visualization. Examination of software designed to be used in the geometry curriculum and software designed to help improve visualization skills.

Session 7: Inverted Curriculum. What can each individual person, department, school, or district do to integrate computers into the math curriculum? Do we need to teach math topics in the order that we are currently teaching them? Can we start with generalizations and work backward to a specific algorithm? This session consists mainly of lecture, and small-group and large-group discussion.

Session 8: Project Reports and Closure. Inservice participants, individually or in small groups, have been working on term projects throughout the inservice. This final session is devoted to project reports and final questions and discussion. An evaluation of the inservice is also conducted.

Section 5: Instruments and Evaluation

The NSF project used a variety of instruments for needs assessment, formative evaluation, and summative evaluation. Copies of these instruments and a discussion of some of the results are included in Section 5. The NSF project inservices placed considerable emphasis on formative evaluation, and we recommend that workshop leaders do likewise. Such an emphasis will help workshop leaders adjust their presentations to meet the needs of participants.

Readers are also encouraged to study Seymour Hanfling's doctorate dissertation, which was completed in the fall of 1987. Hanfling's work focused on formative evaluation of the NSF project. His dissertation was directed by Dick Rankin (the project evaluator) and Robert Sylwester. It provides substantial information about the effectiveness of the project during its first year. Additional detailed information on the long term effects of the project are discussed in Vivian Johnson's doctorate dissertation completed in summer 1988 under the direction of Dick Rankin and Dave Moursund.

EFFECTIVE INSERVICE

1.1
What the Research Literature Says

Change is difficult. It is difficult to imagine, difficult to plan for, difficult to implement, difficult to manage, and difficult to measure. Fullan (1982) states that, in the educational context, "change involves 'change in practice'" (p. 30) and he demonstrates several difficulties. For one, change is multidimensional; new materials, new teaching approaches, and alteration of beliefs must be considered.

Inservice training is a major tool in the implementation of educational change. In reporting a research-based model for such training, (Gall & Renchler 1985), the authors state, "No one yet pretends to have discovered all the elements that make staff development programs completely successful" (p. 1). One reason for this is the difficulty in designing studies that can "tease out" the effective practices from the background noise of incidental and uncontrolled effects. The most reliable measure of effectiveness—change in student behavior—is several steps removed from the major actions of most staff development programs. Joyce and Showers (1983) describe a model involving classroom-level coaching that promises to take the training all the way to the level of observation of actual classroom practice, but such designs are rarely implemented due to limitations of time and funding.

Because change takes time and is best viewed as an ongoing process, the internal state of the learners—in this case, teachers themselves—is an important consideration. Hall (1982) showed that it is desirable to match inservice to current levels of concern of the individual participants. Furthermore, continued tracking of the evolution of their level of concern can function as a diagnostic tool for modifying the content of training "on the fly," should modifications be necessary.

The literature on inservice designs that are specific to computer education is sparse. Gabel (1984) reviews the work of Isaacson (1980), Winner (1982), and Ferres (1983), and finds, that their essentially descriptive studies do not speak to the issue of effectiveness, but instead concentrate on the mechanics of developing and presenting special purpose inservice training. Gabel's own work concluded that the model suggested by Gall and Renchler (1985) was a valid and useful framework for organizing computer education inservice.

In this section, the categories for the dimensions of inservice follow those outlined by Gall and Renchler (1985) and are divided into five categories: content and organization, delivery system, organizational context, governance, and evaluation.

Inservice Dimensions

Content and Organization. The realm of the planning, development, delivery, and follow-up of actual training sessions is below the level of more global concerns such as the environment in which inservice is provided, the goals and standards of the institution whose teachers are being educated, or the measures by which the inservice program is to be evaluated. Of course, these global issues have great impact on the training to be delivered. For example, the environment may determine the resources, timing, extent and depth of the program. The goals and standards of the institution (e.g., a school district) should strongly influence (if not actually determine) the content of the program. The measures of evaluation may direct the attention of the trainers to emphasize more closely monitored elements of the program at the expense of other elements less emphasized by the evaluation instruments.

Nevertheless, the actual conduct of an inservice may be separated from these other concerns, and a large body of literature (accompanied by a much smaller body of research) is available for inspection. The predominant feature of the literature is that it is generally based upon common practice, rather than upon actual research. In fact, the *management* and *evaluation* of inservice training is more thoroughly researched than the *conduct* of inservice.

Gall and Renchler (1985) identified the dimensions of methods of delivering an inservice:

1. *Readiness activities*. What actions are taken prior to the conduct of training to raise teacher awareness of the importance of the inservice program? How are school leaders prepared for their roles in the training? What participant information is gathered before the program begins?

2. *Instructional process*. What training methods will be used to help teachers acquire the target knowledge and skills?

3. *Maintenance and monitoring*. What provisions are made to observe and measure the actual level of application of the content of the training to classroom practice?

4. *Training site*. Is the training best carried out at the school site, or is another location more appropriate?

5. *Trainers*. What trainer characteristics may impact the effectiveness of the training program?

6. *Scheduling*. What duration, spacing, and timing should the training program have?

Competently designed inservice training programs will address each of these dimensions. The usual practice of trainers is to give great attention to the instructional process, scheduling and their own preparation.

An additional question to be addressed might consider any practical distinctions that exist among different types of learners. Are adults in general (and teachers in particular) sufficiently different from other learners that exceptions or refinements must be made to the well-researched principles of learning? (see Gagné, 1977) Although the most general of these learning principles remain intact, researchers such as Knowles (1978) have determined that adult learners are sufficiently different from children as to merit distinct consideration. Among the important features of adult learners cited in Knowles' work are that:

1. Adults learn by doing; they want to be involved. Mere demonstration is usually insufficient. Practice and even coaching are highly desirable.

2. Problems and examples must be realistic and relevant to them *as adults*.

3. Adults relate their learning very strongly to what they already know. They tend to have a lower tolerance for ambiguity than children, so explicit attachment of new knowledge to their existing base is a paramount necessity.

4. Adults tend to prefer informal learning environments, which are less likely to produce tension and anxiety.

5. Changes in pace and instructional method tend to keep the interest of the adult learner high.

6. Unless the conditions of training absolutely require it, a grading system should be avoided. Checklists of criteria met in the course of training, for example, are less intimidating than the assignment of grades.

7. The instructor should frame his or her role as that of a facilitator of learning rather than as a font of knowledge or expertise. This guarantees that participants will find the trainer approachable, an absolute precondition of communication between adult learner and teacher.

It is obvious that these adult learner characteristics are of great concern to the teaching of adults and they should govern several aspects of the preparation, delivery, and follow-up. The impact of these elements of training is discussed below in summary with lessons learned from other sources.

In a study of the impact of inservice on basic skills instruction, Gall et al. (1982) identified a number of deficiencies in the ordinary conduct of inservice:

1. Programs tended to be focused on the professional goals of individual teachers rather than on the improvement of the school instructional program. Teachers' goals and school needs are not always in consonance.
2. One-shot training or short sessions failed to show impact on the school's instructional program.
3. Although the inservice programs were sponsored and financed by districts or schools, the general plan and learning activities of the training were based on goals and objectives that had little or no demonstrable connection to those of the school or district.
4. Programs were very rarely assessed on the basis of actual improvement of student performance.
5. Most inservice programs lacked several of the following desirable features: readiness activities, a meeting, follow-up activities, and in-classroom observations to identify changes in teacher behavior that might be attributed to the inservice training.

These researchers judged that programs exhibiting such deficiencies will have little impact on teacher practice or student performance.

Much of the work of Joyce and Showers (1983) centers on governance issues, but they also have critical points to make concerning the conduct of inservice:

1. Training may be considered to be composed of levels of involvement: lecture, demonstration, practice in the training environment, practice in the target environment, and coaching in the target environment.
2. Generally, lecture and demonstration have little impact in terms of changing teacher behavior.
3. Practice (following lecture and demonstration) contributes greatly to change in teacher behavior.
4. Coaching (following lecture, demonstration, and practice) not only contributes further to change, but also creates opportunities for dissemination of an innovation or desired practice throughout the unit (e.g., department, school, or school district) in which change is desired. One of the most promising of these opportunities is peer coaching.

Echoing elements of both Knowles (1978) and Joyce and Showers (1983) are some of the findings of the Florida State Department of Education (1974):

1. Inservice programs that place the teacher in an active role are more likely to accomplish their objectives than those which place the teacher in a receptive role.

2. Programs that emphasize demonstration, supervised trials and feedback are more successful than those that simply present new ideas or materials to teachers without opportunities for practice.

3. Programs in which teachers share and provide mutual assistance to each another are more likely to succeed than those that fail to encourage interaction during and after training.

4. Self-initiated and self-directed training activities (although seldom used in inservice education programs) are associated with successful accomplishment of program goals.

The literature offers many similar indicators of success or effectiveness in inservice conduct.

They are briefly summarized as follows:

1. The content of inservice education programs should be directly and immediately linked to the goals of the agency sponsoring the training.

2. The characteristics of teachers as adult learners should be taken into account when inservice education activities are designed. In particular, the activities should be relevant to them as adults, new knowledge should be explicitly connected to previous knowledge, an air of informality should predominate, grading systems should be avoided, and the trainer should act as a facilitator.

3. Designs that feature multisession contact and development of an ongoing relationship between trainer and teacher is preferred over one-shot designs.

4. If possible, the training should include not only presentation of information and demonstration of new methods and skills, but also supervised practice and coaching.

Organizational Context. When referring to the organizational context in which inservice education occurs, Gall and Renchler (1985) echo the "modal systems" of Joyce and Showers (1983). While Gall and Renchler recognize the five modes identified by Joyce and his colleagues, they prefer to think of these modes as representing different functions of inservice education and go on to identify four such purposes: (a) inservice for personal professional development; (b) inservice for credentialling; (c) inservice for the purpose of induction into the profession; and (d) inservice for school improvement.

"Inservice for school improvement" speaks directly to the school as an organization. Operationally, one can define the organizational context as those organizational elements of the school that directly influence the success of inservice education. But organizational context also implies a series of interrelated components that work in relative harmony. To divorce any one component from the whole distorts our perception of and reaction to that element. Just as our perception of our environment is continuous, so the school must be viewed holistically as a continuous, dynamic collection of interlacing and interactive parts.

A meta-analysis done by Lawrence and Harrison (1980) concludes that the most effective inservice programs address the school as a unit. Their research supports the contention that inservice is most effective when the emphasis is on global goals rather than personal development.

These findings are consistent with the observation of noted anthropologist Edward T. Hall (1981) about the essential nature of the context of expression and action. He states that context determines everything about the nature of the communication and predicates further behavior. A focus on school improvement places the "situational dialect" of the teacher professional life of the teacher within the larger frame of the school as a complete unit. This broad focus of shared goals gives a context of discussion in harmony with the larger organizational context. A somewhat different but complementary observation is made by Pitken (1972) when she examines the question of social membership. She notes that with respect to learned or cultural norms, the wholeness and uniformity of our society is determined by the acquisition of like patterns by people exposed to them. These views lead again to the conclusion that the more consonant the goals are with the school, the more consistent will be the patterns of compatibility between the behavior elicited and those expressed by the administration and support staff. In essence, the new behaviors or activities must mirror the intentionality of the school as a unit.

If we place the goals of the inservice within the larger framework of the school environment and provide a collegial support structure, chances of institutionalizing any changes are improved. In a fundamental sense, the organizational context provides the ecological gestalt of action and interaction. Compatibility between the objectives of the inservice and those of the school is essential if changes are to be made a part of the taken-for-granted background of the teacher, administrators, and support staff in their daily activities.

Holly (cited in Gall & Renchler, 1985) surveyed 110 teachers and found a general preference for activities that allowed them to work with other teachers. Ngaiyaye (cited in Gall & Renchler, 1985) found that teachers preferred to work with teachers who had similar educational duties. Domain-specific knowledge as defined by Doyle (1983) consists of an explicit semantic network of relevant information and identified methods or strategies for applying that information. Although Doyle was addressing academic content, it seems clear that the same theme can be applied effectively in inservice education. Thus, not only does educational research support the need for teachers to work with teachers, but it supports a more specific domain of discourse in which they share their goals and concerns with teachers in their own or similar subject areas. In a collegial environment made up of their peers, teachers can relate common concerns and share methods or strategies central to their needs as educators (U.S. Department of Education, 1986). Furthermore, teachers with similar instructional assignments can share materials, tools, and new methods of instruction.

Unfortunately, there appears to be no research examining the relative effectiveness of variations in teacher inservice groupings as defined by Gall and Renchler (1985). Wade (1985), however, does indicate in her meta-analysis that participation by both secondary and primary school teachers is more effective than either group working alone.

In an organizational context, the school principal as an instructional leader plays a major influential role. Research by Louchs and Pratt (cited in Gall & Renchler 1985) indicates that the role taken by the principal in the implementation efforts of a program is essential to the success of the project. Leithwood and Montgomery (cited in Gall & Renchler 1985) have shown that an effective principal will participate in at least part of the inservice workshops attended by the staff. Finally, the Rand study (cited in Gall & Renchler 1985) suggests that without the approval of the principal, teachers generally will not implement a new curriculum or process.

As noted above, the school is a dynamic but loosely coupled organization. This loose coupling requires a mediating force that lends a coherence to its structure. Thus, the principal seems to act as a lens to keep school goals clearly in focus and as a guide to keep teachers on track with district objectives (U.S. Department of Education, 1986).

Governance. The issue of governance frames the larger context of school as a functioning unit. Operationally we can define governance as that organizational process of decision making that determines school policy and directs school resources. The governance of inservice education specifically addresses concerns about the way an inservice will be designed and offered to the district staff. The study by Mertens (1982) clearly shows that the view of the teacher as a professional must pervade the district; when teachers are viewed as professionals, inservice projects are more successful than when teachers are viewed merely as functionaries. All projects and or policy decisions need to be approached in this light.

There appears to be no research on the most effective infrastructure for carrying out the process of governance at the district level. However, there is ample research to indicate that this process must take into account teacher concerns and expectations. Many researchers indicate that the teacher must be given the opportunity to be part of the planning. If teachers are not consulted, the results can be disastrous. Wolcott (1977) documented a carefully planned effort for educational change in a school district in Oregon. This mammoth seven year plan involving several hundred thousand dollars, vast district resources, and uncounted hundreds of hours for both planners and teachers failed. Its primary failure was that it did not take into account the needs of the educator. It was conceived as a "top-down" approach and implemented as such.

Wolcott reaffirms the importance of teacher participation in the planning process. What is not clear is how much control teachers should have over the inservice content. On one side is the work of Schurr (cited in Gall & Renchler, 1985), where it is shown that teachers desire input into the planning process; on the other side is the work of Wade (1985) that indicates inservice sessions were gauged as "less successful" if participants were regarded as the major contributors to the process. Indeed, her meta-analysis shows that inservice sessions are more effective if the leader assumes the role of "giver of information" and teachers as "receivers of information." Clearly, a balance seems necessary. It is important to ascertain the needs of teachers so that inservice sessions can be directed specifically to their needs. On the other hand, the integrity of the inservice content must be maintained, with policy and planning decisions attempting to strike a balance between teacher input and district needs.

Another issue of governance is the recruitment of participants. Motivation to attend inservices can be subtly but definitely enhanced if the research outlined in this section is taken into account. A feeling of personal connection with the concerns of the inservice is also important. Moursund (1988) suggests that ownership in a problem-solving process is critical. Inservice by definition is a form of problem solving. If participants can feel a sense of ownership of the content of the inservice, they will want to attend and take seriously the purposes of the project.

Wade (1985) confirms the need to have a sense of ownership, pointing out that inservice is more successful when the teachers are given special recognition for their involvement. But she further reports that projects are more successful if teachers are either designated to attend or selected on a competitive basis. Clearly, the research confirms the need of teachers to be a willing part of the process, but it also indicates that directing teachers to attend is not predictive of failure. Obviously, this is a complex issue: *How* teachers are directed to attend is important; the content and relevance of the inservice is important; the organizational context is important; and the way the issue of governance has been handled in the school is historically important.

Other incentives for attending inservices described by Betz (cited in Gall & Renchler, 1985) are release time, expenses, and college credit. Administrators, however, can take heart in Wade's (1985) finding that almost any inservice can make a difference. She reports that inservice of any kind, on the average, resulted in half a standard deviation greater positive change than control groups. This is a clear indication that inservice education can influence the quality of the education.

In summary, effective inservice must take into account the school organizational context and its governance policies. It appears that the more the inservice speaks to the unifying goals of the school, the more effective will be the results.

Evaluation. As stated in Gall and Renchler (1985): "The evaluation of inservice programs is not a well-developed field," and "... systematic evaluation of inservice programs is the exception rather than the rule" (p. 30). In an effort to bring some order to the field, Gall and his colleagues (1976) attempted to define the different levels at which inservice training might have effects. They defined four levels:

Level I: Implementation of the inservice program. (Measures of the quality of the training itself.)

Level II: Teacher improvement. (Measures of actual change in teacher behavior in the classroom.)

Level III: Change in student performance. (Measures of the degree to which improvements in teacher performance lead to improvements in student achievement.)

Level IV: Changes in the environment. (Measures of changes in the school that may be indirect [or even unintended] results of the inservice program.)

The further away we get from measuring the direct delivery of training, the less certain we can be that changes in Levels II, III, and IV are actually attributable to the training program. Other factors, unpredicted and unmeasured, may have greater impact than training.

At Level I, the elements mentioned previously in the Content and Delivery System section (readiness activities, instructional process, maintenance and monitoring, training site, trainers, and scheduling) should be measured directly. In addition, some quantification of the degree of relevance of the program to teachers' perceived and actual needs should be attempted.

At Level II, the best measures are those of increased teacher competence. If the program is of novel content (as a computer inservice might well be), conventional measurements might have to be supplemented with new ones that reflect the content of the training. Observational measures of actual classroom practice are the preferred instruments.

At Level III, measures of student achievement are appropriate. Because this level is rather far removed from the training, it may be difficult to attribute changes in student behavior directly to actual inservice practices.

At Level IV, we hesitate to suggest methods of measurement. Although instruments can be created to measure school climate and levels of intercommunication among the staff (Joyce, Hersch, & McKibbin, 1983), it is perilous to presume explicit connections between an inservice program and a change in the school environment.

Conclusion

To narrow the scope of the literature on effective inservice, this review concentrates on literature dealing with the actual conduct of inservice.

The five dimensions of inservice (i.e., content, delivery system, organizational content, governance, and evaluation [Gall & Renchler, 1985]) were used to examine the literature. The predominant feature of the literature is its bases in common practice, rather than on actual research. Literature specifically related to implementing changes in educational computing is extremely limited. The literature that exists concentrates on the delivery system aspect of Gall's classification.

Currently, staff development is the major tool for implementing educational change. Reviewing the literature confirmed our intuitive belief that effective inservice is difficult to attain for the following reasons:

1. Change is multidimensional. (We are dealing with change in a school system, and a school system is a very complex entity.)
2. Change is a slow process. (It is the nature of a stable and functioning system to resist change. School systems seem to be exceptionally resistant to change, and change only slowly.)
3. Effective inservice is resource intensive. (In many settings the resources available for inservice education may not be adequate to produce a significant change.)
4. Learning styles of adults are complex. (A typical inservice will involve adults with widely varying interests, characteristics, and backgrounds.)
5. Global characteristics of school systems, many of which are outside the influence of the inservice provider, influence change.
6. Participation of teachers in the process of setting goals for inservice may enhance the learning of the participants, but it is difficult to properly achieve this participation in goal setting.
7. Mechanisms for evaluation of inservice programs are ill-defined and infrequently attempted.

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1.2
THE CI^3 MODEL FOR EFFECTIVE INSERVICE

(Note: This is a slightly modified version of a paper written by Seymour Hanfling, Judi Mathis, and Jim McCauley for presentation at the University of Oregon "Extensions of the Human Mind" conference in August 1986. These three authors were all members of the NSF CI^3 project staff when the paper was written.)

The Computer-Integrated Instruction Inservice (CI^3) project directed by Dr. David Moursund began in September 1985. The purposes of the three-year project: were (a) to develop an inservice model for educating teachers in methods of integrating general computer software tools such as databases, spreadsheets, graphics programs, science tool kits, into their curriculum; and (b) to develop a method for training inservice trainers in the use of that CI^3 model.

During the first year the project team concentrated on developing the inservice model and materials in two areas: elementary schools and secondary school mathematics. The second year of the project continued this teacher inservice development and extended it to include secondary school science. It also developed an inservice to train trainers in the use of the CI^3 model. The third year will refined the materials from the second year, created materials for secondary school social studies, and began dissemination of the results of the project.

The ultimate goal of the CI^3 project is to bring about improvement in the classroom; this is a formidable task. The process of bringing about improvement through innovation in the classroom by staff development has been studied extensively (Berman & McLaughlin, 1978; Dillon-Peterson, 1981; Fullan, 1982). Even though there is no agreement on the "one" best way to do staff development, there is agreement on the need for the support and involvement of the major components of an educational system: the teachers in a school or department, the building administration, the central administration, the school board, and the students' parents. The CI^3 project used this knowledge in formulating an inservice program.

First, we received the support of the central administration of the district within which the workshops took place. Second, we viewed the school (or department in the case of a high school) as the unit of change, not the entire district. We worked with groups of teachers from a building (or department). Finally, an administrator from each building was required to participate along with the teachers. As Wood, Thompson, and Russell (1981) point out:

> For staff development to have a lasting effect, the principal must be committed to the implementation of the inservice goals, participate in the inservice planning and activities, encourage other staff members to participate in training programs, and support and reinforce the implementation of new knowledge, skills, and strategies. (p. 63)

During the first year of the project we were quite successful in getting school administrator participation in the project. During the second and third years we were less successful. There is a substantial body of theory on how to organize and conduct an inservice to be as effective as possible. It usually turns out that there is a substantial difference between the theory and what one is actually able to accomplish. In this case, we were not able to secure school administrative participation at the level we would have liked during the second and third year.

During the first year, the CI^3 project worked with two groups of educators. One consisted of the principals and a number of elementary school teachers from three schools. The second consisted of mathematics teachers from a middle school and a high school and an administrator from each building. There were approximately 17 participants (all volunteers) per group.

Prior to the training, a needs assessment was conducted by interviewing all the participants. We acquired knowledge on a variety of topics, including the participants' current educational and personal computer usage; their access to computers, computer lab(s), and software; their views on educational uses of computers; and the areas in which they desired training.

Originally seven inservice sessions were scheduled. The sessions were conducted after school and usually at the computer lab sites of the participating schools. (Two sessions were conducted on the University of Oregon campus.) The introductory and closing sessions were originally scheduled to be five hours long (with dinner provided), and the five other sessions were to be two hours in length, held every other week. The teachers found the first five-hour session to be too long after teaching all day. We adjusted our schedule and shortened the last session to two and a half hours. As a result of this experience, we redesigned the second and third year inservices to consist of 16 hours of workshops in eight two-hour sessions.

The Inservice Model

> The wise leader knows that the true nature of events
> cannot be captured in words. So why pretend?
> Confusing jargon is one sure sign of a leader who does
> not know how things happen.
>
> *The Tao of Leadership* by John Heider

Inservice Design Principles

The participants in our inservices reflected a wide range of backgrounds and teaching environments. Although this lack of homogeneity is a common difficulty in computer-related inservice education, it led to the development of a significant premise of these workshops.

Clearly, these workshops are *not* inservice *trainings* in the sense of teaching a specific teaching technique, computer management skill or even competence with a specific piece of software, but instead are *educational* workshops. They are meant to expand teacher knowledge and capabilities in the classroom, and they provide an environment for exploring and learning about the applications of computers and software tools in the curriculum.

The issue of training versus education is critical. Computers will be part of education from now on. All teachers will eventually need to deal with computers in schools. Computer inservice for teachers needs to be an appropriate blend preparing them to make some immediate use of computers, but also laying a firm foundation for continued growth and learning in this field. It was our observation that many inservices on computers place too much emphasis on what keys to press and the specific details of particular pieces of software. Many inservices of this sort do not do a good job of developing computer-related foundational knowledge such as general roles of computers in problem solving, changes in education needed to prepare students for life in an Information Age society, etc.

The following design principles were used to create the balanced environment we deemed to be appropriate:

1. Each session should offer participants at least one idea that can be used immediately or in the short term future in their classrooms. This idea might be an activity, a piece of software, a teaching style, or a management aid. The sessions are rich learning environments in which participants discover and experience many ideas and applications of computer-related activities and software tools. These environments provide many opportunities for participants to find ideas that are appropriate and relevant to their instructional situations. The process of discovery also helps build ownership and increases the likelihood of classroom implementation.

2. Software should always be introduced in an instructional context. Rather than training participants in the details of a piece of software, the tool is introduced with classroom examples. Activities are designed so the participants can be successful even if they have only partial knowledge of the software. This allows teachers to see that they need not understand all of the nuances of a program before they use it in the classroom. There are two reasons for this approach: First, it helps teachers explore and gain an understanding of the instructional uses of a specific software tool. Second, it provides a model for teachers to experience an activity and begin to adapt the activity to their own classrooms.

3. Participants should experience activities on two levels. First, as "students" in an inservice, are the activities meeting the objectives? What is being learned? What is being experienced? Is it enjoyable? Second, they are asked to analyze the activities and the inservice itself: What activities have been chosen? Why have those activities been selected and not others? How can those activities be adapted to their classroom?

   Reflection and discussion of these questions occurs at different times. The participants are briefly reminded to note and reflect on the first questions while they are doing an activity. These questions are then repeated during the closure discussion for an activity. The second set of questions is also discussed during closure for an activity and at the closure for the entire session.

4. The participants should work in groups. There are four reasons for this. First, Cox and Berger (1985) have shown that working in groups on the computer is more effective in solving problems than working individually. Second, the participants become accustomed to discussing computer-related curriculum matters with each another. This helps build a school level and district-wide resource base, and it builds a spirit of mutual support among the inservice participants. Third, it allows the trainers to work with more of the participants. Finally, it allows the trainers to eavesdrop on participants' conversations and gain relevant information for conducting discussions and directing the remainder of the session.

   In recent years the effectiveness of cooperative learning has become clear. Many people fear that computers will be used to isolate students and work against against the cooperative learning environment. But this need not be the case. Many computer activities can be done in a cooperative learning environment, and research supports this approach as being good.

5. Each session should be structured to allow participants to discover methods and models of instruction. The participants demonstrate or gain an understanding of these methods during the debriefing of each activity or at the session closure. This approach differs from many prevailing inservice formats by avoiding an explicit statement of inservice objectives at the outset of each session. Our goal is to avoid creating a specific mind-set in participants that may deter them from making their own original observations or restrict them from making additional observations. It also allows them to experience the activities as their students

might, thus providing valuable insights that can be gained in no other way.

Imagine, for a moment, a scale which is labeled "Pure Discovery" on one and "Pure Directed Instruction" on the other end. Most of the instruction in our schools is conducted using a style that is much closer to the Pure Directed Instruction end than to the pure Discovery end. But it is essential that both teachers and students learn to use computers in a discovery-based mode, so that they feel comfortable in working with new software applications and learning on their own. Thus, in designing the inservices, we made a decision to place major emphasis on discovery-based learning about computers. We reasoned that if teachers learned about computers in this type of mode, they would then use it with their students as they introduce computers into their classrooms.

This method requires the development of mutual trust. Through the activities the participants discover, learn and gain insights across many pedagogical domains. During the debriefings the trainers can aid the participants in understanding and adapting their insights. This discovery and debriefing-oriented model is stimulating, interesting, and successful.

A key aspect of discovery-based learning is the debriefing periods at the end of discovery sessions. The course instructor (the facilitator) must have a clear picture of the key elements that are to be discovered. (Of course, it usually happens that many additional important elements are discovered.) The debriefing sessions allow participants to bring up and discuss the ideas that they have been working on and discovering. The facilitator must ensure that all key elements are brought up and that they receive appropriate emphasis.

6. The sessions should be *enjoyable!!!* There has been substantial research on the relationship between attitude and learning. We know that if participants are enjoying the learning experience, they will learn more and better.

Material Selection and Development of Activities

The main reasons that computers are so heavily used in business, government, and industry is that they are a powerful aid to problem solving and productivity. Computers can solve or help to solve a wide range of problems. The focus of this CI^3 project is to improve student problem solving by integrating of software tools (e.g.,graphics, databases, spreadsheets, science kits, etc.) into the curriculum. Thus, the theme of problem solving is interwoven throughout the design of the inservices. Inservice participants can explore and experience the use of these tools by solving problems presented in the inservices. These experiences also encourage participants to discover new ways to pose problems and even new types of problems to be solved.

Problem posing and problem solving are higher-order skills, essentially corresponding to the Analysis, Systhesis, Evaluation end of Bloom's taxonomy of cognitive skills. There is a strong and growing movement in our school system to place increased emphasis on such higher-order skills. Computers are a vehicle that can help in this endeavor.

Problem posing and problem solving are interdisciplinary skills. They are not, as many teachers think, just mathematics. All teachers should have their students pose and solve problems. All teachers should teach problem posing and problem solving as part of their overall curriculum

Due to the wide range of backgrounds and experiences of the participants, as well as gender differences, careful selection of materials and activities is important. However, selection of software is also limited by practical constraints. Our selections are based upon availability, quality, utility in the particular inservice situation, appropriateness to the grade and concept level, and effective cost. The last item refers to software that is under district license, in the public domain or allows multiple loading. (Some software companies give special permission for multiple loading to educators conducting teacher training.)

After the design of activities and selection of software, performance aids and learning aids (worksheets) are developed. *Performance aids* contain the basic information necessary to use a piece of software; keystroke commands, data retrieval and printer commands, for example. Many participants find that they can use unfamiliar software with a minimum of instruction if supplied with an appropriate performance aid. Participants can also learn to use some software through on-line tutorials. *Learning aids* contain problems that increase in complexity and software knowledge; therefore, they may contain software comments where appropriate (e.g., how to print a graph). These worksheets range from very specific instructional sequences to open-ended explorations.

Along with performance and learning aids, sample lesson plans are provided, which can be adapted, extended, and used as models. They are important in assisting participants to transfer inservice concepts to their classrooms, and reduce the amount of effort required to develop and transfer new activities to the classroom.

Organization and Development of an Inservice Script

In organizing the sessions we tried various inservice methods and activity sequences. The ones we found successful were those that embodied our assumption that instruction is a dynamic process by nature. Decisions are made continually through the interactions of the trainers, the participants, and the content being presented. Thus, the framework of these sessions must be flexible. The same session presented with different groups of participants might begin in the same way, but then, based upon their responses and needs, proceed along different paths. Many times the participants are offered a choice of options or they are allowed to offer their own suggestions on the next step in the inservice. This dynamic process is difficult to capture in words. In the following discussion it is important for the reader to keep in mind that these inservices embody a process that is designed to be flexible.

Sequencing of Activities. The sequencing of all activities enhances concept attainment and assists in the transfer of these concepts to the classroom. The sequencing of activities begins with the most concrete activities and progresses to the more abstract.

The typical sequence for an activity is:

1. *Explore.* Allow participants time to "play," so that they may develop an intuitive understanding of the software or activity. Participants make use of a Performance Aid.

2. *Experience.* Work on the software or activities in an instructional format that models classroom presentations. Participants make use of a Learning Aid.

3. *Discuss.* Debrief the activity, paying particular attention to participants' feelings, experiences, attitudes, and ideas for instructional applications. The facilitator makes sure that key ideas that the lesson was designed to cover were indeed covered and get discussed during the debriefing. But keep in mind that the debriefing is to be conducted in a discovery based mode. The facilitator should avoid, as much as possible, switching into a directed instruction mode during the debriefing.

4. *Closure.* The facilitator gives a brief summary statement. Relate this activity to the objectives of the session or previous sessions. Integrate previous participant comments as frequently as possible during closure.

Sequencing within a session. We begin each session with a hands-on activity or an off-machine problem solving activity that is approximately 5-15 minutes long. (We strongly encouraged participants to work in pairs on the computers. Sometimes a person would decide to work alone, and sometimes three people would work together.) This instant involvement is very useful in setting the tone for the day's session. It allows participants to begin participating as soon as they arrive, and it handles the situation of some participants showing up a little late. The debriefing of this opening activity provides an opportunity to discuss the focus and general goals of the session. (A general goal might be to explore uses of computers to store and retrieve information as an aid to solving problem.)

The next 30-40 minutes is spent exploring activities on the computer with participants working in groups, generally in pairs. This exploratory period might be directed by the trainer or through performance and learning aids, with a focus on the specific objectives of the activity. Participants may become involved in trying to "solve the puzzle" or "beat the computer," and it is sometimes necessary for the trainers to draw the participants' attention to the instructional aspects of the activities. The participants may finish an activity at a later time and at their own pace.

The debriefing of all activities is extremely important. As described above, explanation and debriefing of all activities follows rather than precedes the activities. This allows participants to experience an activity in a situation without a trainer-induced "mindset" and places them in a similar position to that of their students. Encouraging participants to generate ideas contributes to the transfer of ideas from the inservice to their teaching situations. It is more likely that teachers will try new classroom practices if they have experienced these new practices in the workshops and then analyzed and reflected upon them.

The remainder of the session is spent intermixing off-computer and computer-based activities. The participants enjoy the integration of off-computer activities into the sessions. The concrete nature of these activities provides a bridge to the abstract nature of the computer.

Final closure for an entire session provides a transition from the inservice setting to the classroom. Our experience indicates that the integration of software tool activities into classes seems to take place if the integration (a) allows students to learn better, faster or in more exciting ways; (b) allows students to work with more important concepts than they are now learning; and (c) is not appreciably more difficult for the teacher than present instructional practice. Discussions during final closure are useful in generating ideas that illustrate these points.

Once the above ideas have been used in planning a session or series of sessions, it is important to review the entire set of activities. Are the transitions smooth? Are the activities building upon each other? Are the original objectives still being met? (The last question can sometimes be overlooked as "exciting" activities and software hide or even change the original objectives.) Finally, is this still a inservice that is interesting and enjoyable to lead and experience?

Inservice techniques. Like any teachers, we use a variety of techniques during the sessions. The following are those we find useful and consider the most important:

1. Model classroom activities and appropriate teacher behaviors. We generally teach the way we have been taught. The importance of modeling appropriate teacher behaviors cannot be overstated in helping participants to integrate new ideas into their classes. Merely "discussing" how activities can be done in the classroom is insufficient; they must be *experienced* in order to be understood. (Note that there is some research that suggests that elementary school teachers like to be in inservices that model appropriate behavior, and that secondary school teachers are less supportive of such an approach to inservice education.)

2. Identify and utilize participants with knowledge of the inservice contents. (No matter how carefully one states the prerequisites and describes the intent of an inservice, the participants will have widely varying backgrounds. Frequently there will be one or more participants who are quite qualified to be facilitating the inservice.) Forming groups where at least one of the participants has experience with a piece of software can help make workshops go more smoothly. Establish peer support by publicly validating participants' knowledge and encouraging peers to consult each other for answers. Remind participants that they are experienced educators who bring a multitude of skills to the inservices. (An analogous situation for teachers is using students in their class who are experienced with software to act as helpers or teachers to other students.)

3. In the debriefings and discussions, encourage participants to analyze the activities from

two perspectives: that of a student (their experiences while using the software) and that of a teacher.

4. Obtain feedback from the participants at each step of the inservice. Be responsive to their needs and, when appropriate, modify the inservice plan. When necessary, help the participants reevaluate their expectations in order to gain the most from the inservice. For example, because a wide range of teacher backgrounds is present at a inservice, a specific piece of software may not fit everyone's teaching assignment. Shift the focus of those teachers toward examining the software for its strengths and weaknesses: Is it easy to use? Is the feedback appropriate? Does it allow for exploration?

5. Do not be disturbed if the time schedule that you have set occasionally requires you to interrupt participants in the middle of an activity. Research suggests that this can actually contribute significantly to learning. The interruption provides a time for participants to reflect upon their experiences during an activity.

6. Use open-ended questions that encourage teachers to reflect on the session's activities. Convergent questions can cover the content and analysis, as well as pacing and sequencing. Divergent discussions can cover transfer of the activities to the classroom and possible impact on the curriculum and individual classes. These types of questions are important and cannot be hurried. A time for reflection and analysis helps participants gain the ownership necessary to integrate new ideas into their own educational setting.

7. When the trainer does not have an answer to a question, the best response is "I don't know, let's see what all of together know about this question." There may be participants that can provide information, just as the teachers may have students in their class who can help them with a piece of software or activity.

Reference Materials, Handouts, and Log Sheets

Each participant receives a set of materials, at the first session including relevant journal articles, software reference lists, classroom ideas and public domain software. Refer participants to elements of this collection whenever related activities or discussions take place.

The participants are asked to keep a log of their computer-related activities, including: classroom lessons, work with individual students, personal use, readings and discussions with colleagues. This log form also can be used to ask trainers for information or help. The trainers respond to questions, suggest software the participants might wish to preview, and return the logs. These forms are an important feedback mechanism. It is an efficient way for participants to communicate with the trainers to have a record of their computer-related activities.

School Visits

Based on the experience from this project, classroom visits should be included as part of the inservice program. This can be done in a variety of ways: A trainer may model a lesson in a participant's classroom; both the participant and trainer may teach a class together; or the trainer may observe the participant teaching a lesson. Many teachers feel that this type of interaction is helpful.

Closing Comments

We have spent many hundreds of hours working on the CI^3 project. It has been difficult to summarize what we have learned, primarily because, as stated earlier, education is a dynamic process. The only way to learn a process is to do it. What we have presented here is a framework that has been effective. However, this is not the end of the development of an effective inservice model. Both formative and summative evaluations have taken place or are in progress; some of the results are given in Part 5 of this Notebook. As you practice using the inservice materials in this Notebook, and as you continue to practice and study the field of inservice education, you will get to be a better facilitator of inservices. One of the joys and frustrations of education is that it is constantly evolving and that educators need to be lifelong learners.

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BACKGROUND INFORMATION

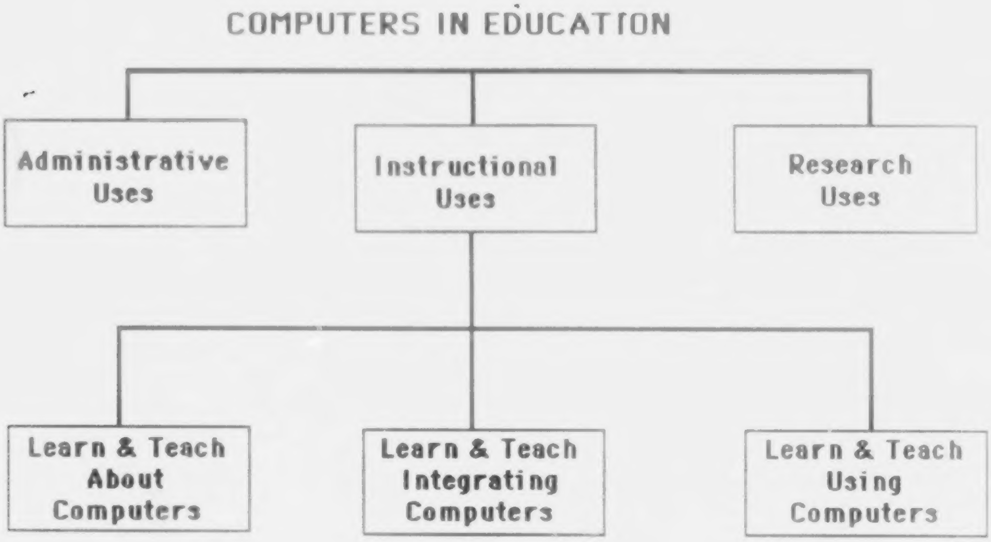
2.1
OVERVIEW OF COMPUTERS IN EDUCATION

Computers are important and widely used in our society because they are cost effective aids to problem solving in business, government, industry, education, and other areas. The primary focus of this Notebook is on the use of computers as an aid to problem solving.

This chapter of the Notebook provides an overview of computers in education, with primary emphasis on Computer-Integrated Instruction (CII). The underlying assumption is that we want to increase students' ability to make use of the computer as a tool in problem solving throughout the curriculum. This chapter might be given to inservice participants as general background reading.

Computers in Education

The diagram below presents a structure of the overall field of computers in education. As indicated in the diagram, the field of can be divided into three main parts. Although each part will be discussed briefly, the main focus is on *instructional uses* of computers. As the diagram illustrates, instructional uses of computers also may be divided into three parts. After briefly discussing each part, we will focus on *learning & teaching integrating computers*. We call this part Computer-Integrated Instruction (CII).


COMPUTERS IN EDUCATION
Administrative Uses
Instructional Uses
Research Uses
Learn & Teach About Computers
Learn & Teach Integrating Computers
Learn & Teach Using Computers

Administrative Uses

Many aspects of running a school system are similar to running a business. A school system has income and expenses. It has facilities and inventories. It has employees who must be paid and employee records that must be maintained. And, of course, a school system has students who must be taught. Detailed records must be kept on student performance, progress, and attendance.

Computers can be cost effective aids to accomplishing all of the administrative-oriented tasks listed above. Thus, it is not surprising that computers are extensively used for administrative purposes in most school districts in this country. In some school districts this use goes back more than 25 years. Overall, the administrative use of computers in schools is growing steadily.

At the current time there are two major approaches to administrative use of computers in schools. One approach is based on centralization. A large, centrally located computer system is used to serve a number of schools, as well as central school district office needs. There may be terminals to individual schools. Thus, some input and output operations may occur at the school sites. Other operations especially those involving large amounts of input and output, occur at the central facility.

An alternate approach that has gained considerable support in recent years is to place administratively oriented microcomputer systems into individual schools. Initially these were self-contained microcomputers, but there is a growing tendency to network them. It has become clear that microcomputers can make a substantial contribution to the functioning of a school office.

It seems evident that there will be a continuing need for a central, powerful computer system in most school districts. Also, it seems evident that on-site microcomputers will become increasingly popular. What is not so clear is how and to what extent the central facility and the on-site microcomputers should be networked together, nor is it always evident which computer applications are best accomplished at the school site and which are best accomplished at the central facility.

The design and implementation of a school district administrative computer system is a task for computer professionals. It takes years of computer education and experience to become well qualified at dealing with this type of task. It is important to realize the level of training and experience needed, since few computer-using teachers have this type of training and experience. In most school districts the instructional computing coordinator does not attempt to also be the administrative computing coordinator, since these positions require such different types of training and experience.

Research Uses

Educational research has benefited immensely from computers. Many educational research projects involve collecting large amounts of data and subjecting that data to careful statistical analysis. If a research project has a control group and a treatment group, students in the two groups may be tested extensively during various phases of the experiment, resulting in a substantial collection of data. Large libraries of statistical programs have been available for more than 25 years. Now such program libraries are even available on microcomputers. Thus, it is relatively easy for a researcher who is knowledgeable in the use of statistical packages to carry out a number of statistical analyses on the data collected.

Computers are making it easier to conduct longitudinal studies. Detailed records can be kept over a period of years. These records can then be analyzed, looking for patterns or trends that might not be evident under casual scrutiny. This type of research is common in medicine, and some of it has been done in education.

Computer-Assisted Learning (which will be discussed later in this chapter) provides an exciting vehicle for research. As students interact with computers while studying a particular subject, the computers can collect and maintain detailed records. These records can be analyzed to help determine which aspects of the instructional program seem to be most effective, and which need modification. Such formative evaluation can provide the foundation to improve instructional materials.

If a school district is large enough to have an evaluator on its staff, the evaluator is apt to be quite knowledgeable in research uses of computers. It is important to understand that administrative, research, and instructional uses of computers are relatively distinct fields of study. A person may be an expert in administrative uses of computers, yet have little knowledge of the statistical packages and statistical techniques of a researcher. Similarly, a person may be an expert in instructional uses of computers but have little knowledge of the hardware and software needed in an administratively oriented computer system.

Instructional Uses

Our diagram of computers in education divides instructional uses into three categories. The categories overlap to a certain extent, but it is helpful to look at each individually. The first one we will examine is **Learn & Teach About Computers.** Learn & Teach About Computers focuses on the discipline of computer science. (A very broad definition of computer science is used, which includes information science, data processing, computer engineering, etc...) This is a well established discipline; many colleges and universities have had bachelor's degrees and/or graduate degrees in these areas for more than 20 years. There are hundreds of journals and magazines that publish the rapidly growing body of computer-related research.

A few high schools began to experiment with teaching computer programming in the late 1950s. This early use of computers in schools provided solid evidence that high school students could learn to program in assembly language or Fortran. However, computers were quite expensive and not particularly accessible for use in high schools.

The development of timeshared computer systems and the language BASIC in the early 1960s opened up the possibility of large number of students learning to write computer programs. As timeshared computers decreased in price, more and more schools began to offer a course in BASIC programming.

By the early 1970s it was becoming clear that computers were beginning to transform our society. The Industrial Age had ended, and the Information Age had begun. Many educators argued that all students should become "computer literate," and that this could be best accomplished through specific computer-oriented coursework. Often the courses were in introductory BASIC programming. The trend toward students taking computer programming-oriented courses increased rapidly as microcomputers became available to schools beginning in the late 1970s.

Now a counter trend has emerged as people realize that it is not necessary to learn to write computer programs in order to make effective use of a computer. Many introductory courses have reduced their emphasis on computer programming and increased their emphasis on using applications software that use the computer as a tool. Computer literacy courses have been developed that contain little or no computer programming. Secondary school enrollments in computer programming and computer science courses have dropped markedly.

The rapid growth of applications-oriented computer literacy courses have caused a number of educational leaders to ask why such instruction must be limited to a specific course. Would it be better for students if computer applications were taught throughout the curriculum? The idea is that students should make use of the computer as a tool in all courses where appropriate. That is exactly what Computer-Integrated Instruction is about, and it is the main focus of this Notebook. CII will be discussed further later in this chapter.

The teaching of computer programming and computer science courses at the precollege level is slowly beginning to mature. A Pascal-based Advanced Placement course has been developed and is now widely taught. This has tended to lend structure to the high school computer science curriculum. However, it is evident that this type of course appeals to only a small percentage of high school students. Enrollment in introductory programming courses that use BASIC, Logo, or other non-Pascal-like languages remains high. On a nationwide basis, however, such enrollment peaked several years ago and has declined substantially since then.

Logo has developed a wide following, especially at the elementary school level. Some teachers view the learning of Logo as an end in itself. However, most Logo-oriented teachers recognize the potentials of Logo as a vehicle for illustrating and teaching various problem-solving strategies. The turtle geometry part of Logo also can be used effectively to help students learn a number of important geometric ideas. The *Logo Exchange*, a nine times per year periodical published by the International Council for Computers in Education, is specifically designed for educators interested in using Logo in schools.

Learn & Teach Using Computers. A computer may be used as an instructional delivery device. This type of computer use is often called computer-assisted instruction, computer-based instruction, or computer-assisted learning. In this notebook it is referred to as Computer-Assisted Learning (CAL).

CAL is sometimes divided into categories such as drill and practice, tutorials, and simulations or microworlds. Most CAL systems include a recordkeeping system, and some include an extensive diagnostic testing and management system. Thus, computer managed instruction is sometimes considered to be a part of CAL.

Initially, most CAL material was designed to supplement conventional classroom instruction. For example, elementary school students might use drill and practice mathematics materials for 10 minutes a day. But as computer hardware costs have declined and more CAL materials have been developed, there is some trend toward implementing substantial units of study and/or entire courses. Declining hardware costs make such CAL use economically feasible. For example, suppose that a small high school has only a half dozen students per year that want to take particular courses such as physics, chemistry, or advanced mathematics. It may be much more cost effective to make such courses available through CAL than through a conventional, teacher taught, mode.

CAL has been heavily researched over the past 30 years. The evidence strongly supports the educational value of using CAL in a wide variety of settings. The success of CAL may be explained by three factors. First, students using CAL on the average spend more time on task. Because learning correlates well with time on task, students on the average learn faster using CAL. Second, CAL materials allow students to work at their own levels and at their own rates. This individualization is a considerable aid to some students. Third, CAL materials can incorporate good practices of instructional and learning theory. Formative evaluation can provide a basis for improving CAL materials under development. Through this approach, the quality of commercially available CAL materials is gradually being improved.

Learn & Teach Integrating Computers. The third category of instructional use of computers is Computer-Integrated Instruction (CII). CII focuses on the computer as a productivity tool, an aid to problem solving. One orientation focuses on general purpose or generic application packages such as database, graphics, spreadsheet, word processor, and telecommunications. Each of these application packages is widely used in business, industry, and government. In education, each can be used at a variety of grade levels and in a variety of courses.

A second orientation focuses on the development of applications software for a specific discipline. For example, there is now a substantial amount of software that can help a person compose music. Such software makes possible the teaching of musical composition to elementary school students. There is a substantial amount of Computer-Assisted Design (CAD) and other graphics artists software. Such software tools are often now centrally used in high school courses that used to focus on drafting or engineering drawing.

It has long been recognized that precollege students could learn to use computers as an aid to problem solving. The initial approach, now dating back more than 25 years, was to have students learn to write computer programs to solve specific categories of problems. For example, it was suggested that if a math student could write a computer program to solve quadratic equations, this indicated real understanding of that mathematical topic. Over the years there have been a number of research studies on whether this is indeed correct. While the results have been mixed, it seems clear that having students write computer programs to solve math problems is not a magical solution to the problems of mathematics education that our schools face.

Initially, such an approach to CII made little progress because both the programming languages and the computer hardware were not suited to the needs of most precollege students. But the advent of timeshared computing and BASIC have helped to change that. And then, beginning in the late 1970s, microcomputers, with built-in BASIC, made it feasible for millions of students to learn to write simple programs to solve specific categories of problems.

It takes considerable time, as well as a specific type of talent, however, to become a competent computer programmer. It was soon recognized that the time was being taken away from the study of conventional subject matter. The movement toward integrating computer programming into various high school courses has long since peaked and has been replaced by a trend toward using applications packages. This new trend has accelerated as better applications packages have become available for microcomputers used in schools. An increasing percentage of this software is specifically designed for use in education.

Word processing can be used to illustrate both the general idea of CII and some inherent associated difficulties. Word processing is a generic computer application tool in the sense that it is applicable across the entire curriculum at all grade levels. Clearly, a word processor is a cost effective productivity tool for secretaries and for many people who do a lot of writing. Moreover, word processors make it easier to do process writing (prewrite, compose, conference, revise, and publish). For these reasons, many schools have decided to have all their students learn to do process writing in a word processing environment.

But it takes quite a bit of instruction to learn to make effective use of a word processor. To learn proper keyboarding techniques and to keyboard faster than one can handwrite takes a typical fourth grade student about 30 minutes a day for eight weeks or more. To learn to compose at a keyboard and make effective use of a word processor takes additional instruction and practice.

There are several additional difficulties. *First*, teachers have to learn to provide the initial instruction and to work with students who do process writing in a word processing environment. Even if the initial instruction is provided by a specialist rather than the regular classroom teacher, the classroom teacher must work with students after the initial instruction. All of the students' subsequent teachers face the same problem. This suggests that large numbers of teachers will need to learn to work with the idea of process writing in a word processing environment.

Second, there is the matter of access to appropriate computer systems. Once a student becomes adept at this mode of writing, the student will want to continue its regular use. This can easily require providing each student with 30 minutes of computer time per day. It also raises the issue of needing to provide computer access for students to use at home, after school, and on weekends.

Third, there is the problem of testing--especially standardized testing. Suppose a student has had several years' experience in using a word processor to do process writing. The student has learned to approach writing projects using this productivity tool. There is a good chance the student can write better and faster using a word processor than using pencil and paper. An appropriate assessment of this student's writing skills requires giving the student access to a computer during the test.

Fourth, once one has a word processor, it is quite helpful to have a spell checker, a grammar/style checker, and an outliner. Such aids to writing may have a significant impact on the nature of the writing curriculum. They may require changes in textbooks, lesson plans, and the way class time is structured. And once again the issue of testing arises. Should a student be allowed to use spelling and grammar checkers when doing writing for an essay test?

These four types of difficulty occur for all CII applications. The problem of teacher training is addressed specifically by the materials in this notebook. The problem of access to appropriate hardware and software will be with us for many years to come. It can be overcome through appropriate allocations of money. The testing problem is being addressed by a number of agencies involved in widespread assessment. For example, some states and provinces now allow use of calculators on certain tests. However, it seems clear that this will be a long term problem. Textbook companies are slowly beginning to address the issue of integrating the computer as a tool into the books they publish. School districts and individual teachers interested in making more rapid progress are developing their own curriculum materials.

The Potential of CII

Many work environments now provide a computer or computer terminal for every employee. It is clear that this will become more and more common, since computers are such useful aids to solving certain types of problems and increasing human productivity. Thus, it seems appropriate to assume that increasing numbers of today's students will use computers when they go to work.

Research on transfer of learning strongly supports the position that instruction and training should closely parallel the final desired behaviors. Thus, if we need workers who are adept at using computers to aid in solving problems, we should integrate computer use as students develop their basic problem-solving skills and strategies. For these and other reasons, it seems clear that CII will grow rapidly for many years to come.

As CII increases, both teachers and students will begin to question the content of many of their courses. If a computer can solve or help solve a particular type of problem, what should students learn about the problem? Is it necessary and appropriate to learn to solve each type of problem using only conventional aids such as books, and pencil and paper? Or, should schools focus more on underlying concepts and help students gain an overall understanding of problems that computers can solve?

In some cases an answer will be forced on schools. For example, libraries are being computerized. Card catalogues are being replaced by computerized information retrieval systems. Important publications are available only in computer databases. Since learning to access information is an essential component of education, students will have to learn to use databases and computerized information retrieval systems.

In other cases schools will have wide options. For example, consider the impact that handheld calculators have had on the upper elementary school and middle school mathematics curriculum. While the potential for calculator-integrated instruction is large, the actual impact on the curriculum has been minimal. This is true in spite of many years of strong support from the National Council of Teachers of Mathematics for integration of calculators into the curriculum. In April 1986, the NCTM issued still another strong statement recommending calculator use at all grade levels. A few states and provinces are now beginning to allow use of calculators in certain testing situations. We may be seeing the beginnings of a trend toward allowing calculators (and, eventually, computers) in standardized testing situations. During the academic year 1987-88, for example, the Chicago public schools purchased approximately a hundred thousand calculators for use by their students.

Much of the short term potential for CII depends on how well our educational system addresses the issue of inservice education. All current teachers can learn to make effective use of CII. Given appropriate inservice educational opportunities, many will do so.

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ROLES OF COMPUTERS IN PROBLEM SOLVING

Each academic discipline focuses on certain types of problems. Each discipline has vocabulary and notation, methodology, and tools to aid in describing and solving its problems. Problem solving is a unifying theme throughout all of education. In this chapter we use the term problem solving in a very general sense, so that ideas such as higher order skills and thinking skills are also included.

Undoubtedly the single most important idea in problem solving is that of building on the previous experiences of oneself and others. For example, consider the importance of language in problem solving. The language(s) you speak and read have been developing over many years, beginning long before you were born. You learned to speak and read many years ago, so that now when you speak or read you are using learning work that you did long ago as well as building on new meanings words have taken on for you.

Paper and pencil provides another type of example of building on the previous work of oneself and others. It is evident that paper and pencil are useful aids to problem solving in every discipline. Paper and pencils artifacts developed and produced by people. When you use these artifacts, you are building on the work of the inventors, producers, and distributors of these artifacts. Paper and pencils are tools that you spent many hours learning to use when you were young. You now use them readily and with little conscious thought of your earlier learning efforts.

The Computer Tool

Now we have a new, general purpose aid to problem solving. (Actually, the electronic digital computer was invented in the 1940s, so it really isn't very "new" anymore. Commercial mass production of computers began in 1951 with the introduction of the UNIVAC I. Most people who talk about the computer being a new tool are people who have been introduced to computers relatively recently. The computer is new to them, so they assume it is new to others.) The advent of the microcomputer beginning in the mid-1970s has made computers readily available to very large numbers of students and workers. However, it is only recently that enough computers have been made available to precollege students to begin making an impact on their education. In that sense, computers are still a new tool in education.

One of the most important ideas in problem solving is that the aids available for solving a problem shape the thinking processes used. You have grown up with books and pencil and paper. When you were a young student, you received many years of instruction in their use. Now, when working on a problem, you automatically consider possible uses of these aids.

For example, suppose that you needed to prepare lesson plans for a course. Perhaps you would first do some brainstorming, writing notes to yourself on the major ideas to be covered, sources of information, time lines, and so forth. Next, you might go to your files and pull out materials you have collected and/or used in the past. Then you might begin to organize, writing new materials and adding to old materials. Perhaps a trip to your bookshelf or the library might be necessary. Finally, you might put it all together in a notebook or in file folders.

This description represents a problem-solving process. It involves careful thinking, drawing on one's knowledge of students, one's own teaching skills, the teaching/learning process, school schedules, etc. It involves creating new materials and reorganizing old materials. It involves information retrieval, organization, processing, and storage. In this problem-solving process you automatically and with little conscious thought make use of reading and writing. The reading/writing tools, which are actually essential to solving the problem, are essentially transparent in the problem solving process. That is, you don't even think about them. Eventually it will be this way with computers, and that is a major goal for computers in education.

A computer can be a useful aid in accomplishing much of the work in solving the lesson planning problem discussed above. However, relatively few people have worked with computers long enough for computer use to be second nature. Indeed, it could well be that most adults today will never achieve this level of comfort or ease in using computers. But students who have the ability to learn reading and writing can also learn how to use the computer as a problem-solving tool. This can be done through computer-integrated instruction which focuses heavily on the computer as an aid to problem solving.

Because computers are still rather scarce in elementary schools, the idea that students may grow up accustomed to the idea of using the computer as a tool may seem rather "far out" to you. But on a national scale we are now in a period of very rapid growth in availability of computers in schools. The value of learning to use a computer with a word processor, spelling checker, and grammar checker is now widely accepted by educational leaders. Many school districts have made the decision that all their students should have such an educational opportunity. Often these school districts are also teaching their students to make use of databases and computer graphics. Eventually these types of problem-solving tools will be a routine part of the elementary school environment as well.

A Definition of a Formal Problem

Every person encounters and copes with a large number of problems every day. Many of these problems are routine and solving them becomes almost automatic. But think for a moment about the variety of problems you deal with in a typical day on the job. For example, as a classroom teacher, you routinely solve problems such as deciding what materials to teach, how to present them to students, how to measure student performance, and how to work with students who are not performing up to your expectations. You attend staff meetings and work on problems faced by the whole school. You handle your personal budget, solving problems on how these funds should be used. It is easy to extend the list, and you should find little difficulty in building your own list. This exercise should convince you that you are an accomplished problem solver and know a great deal about problem solving.

Problem solving has been carefully studied by many great thinkers. There are a number of books that define the concept we call *problem* and explore a variety of problem-solving techniques. (see the references listed at the end of this chapter). We will use the following four components as a definition of problem:

1. **Givens.** There is a given initial situation. This is a description of what things are known or how things are at the beginning.

2. **Goal.** There is a desired final situation (or more than one). This is a description of how one wants things to be; it is a description of the desired outcome.

3. **Guidelines.** This is a listing or description of the general types of steps, operations, or activities that may be used in moving from the Givens to the Goal. Guidelines are the resources and facilities -- that is, the powers of the problem solver. (The Guidelines do not tell one how to solve the problem.)

4. **Ownership.** In order for something to be a problem for you, you must accept some ownership. You must be interested in solving the problem or agree to work on the problem.

The choice of vocabulary (Givens, Goal, Guidelines) is for the mnemonic value of the three G's. Other writers may use different terms. When we say that a problem is *well defined*, we mean that the three G's are clearly and carefully specified. A well-defined problem can be worked on by people throughout the world over a period of time. Progress toward solving the problem can be shared, and cumulative progress is possible. This idea of sharing progress toward solving a problem or category of problems is absolutely fundamental to the human race making intellectual progress.

We frequently encounter problem-like situations that have some, but not all, of the four defining characteristics of a formal problem. We will call these *problem situations*. Often the most important step in solving a so-called "problem" is to recognize that it is actually a problem situation and then do the work necessary to obtain a carefully defined problem. This requires careful thinking, drawing on whatever knowledge one has that might pertain to the problem situation. Often a group of people will have a brainstorming session to get relevant ideas. See especially the works by Torrance. His research and development group has produced instructional material designed to help students gain improved problem-solving skills. See also de Bono (1971, 1973).

Each of the four components may require further explanation in order to become clear to you. We begin with the last one: Ownership. Some experts on problem solving exclude this component, while others give it considerable weight. If coping with a particular situation is essential to your survival, you are apt to have considerable ownership of this situation. But if the situation is a hypothetical (school book) exercise of little intrinsic interest, you may have little or no ownership. Ownership is a mental state, so it can quickly change.

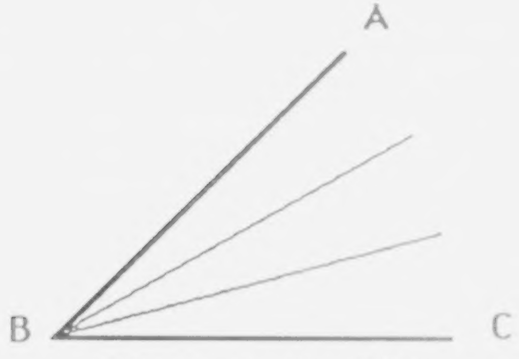
The issue of ownership is particularly perplexing to educators. They recognize that ownership -- that is, a deep interest and involvement with a situation -- often contributes to deep and lasting learning and intellectual growth. Thus, teachers often expend considerable effort creating situations in which their students will feel ownership.

Some alternatives to ownership are apathy and/or coercion. Keep in mind that problem solving is a higher order mental activity. Most people do not perform higher order mental activities well under coercion or while in a "I couldn't care less." mood.

As an aside, you may know some students who have spent literally dozens or even hundreds of hours working on a particular computer program or mastering a computer system. You may have said to yourself, "If only I could get all of my students that deeply involved." It is clear that such ownership of a computer-related problem has changed the lives of a number of very bright and talented students.

Many people are puzzled at first, by the Guidelines component of the definition of problem. Suppose that you were giving your students a spelling test. From the student viewpoint, the task of correctly spelling a word is a problem to be solved. The student would be successful if allowed to use crib notes or a dictionary. What makes the problem a challenge is that these aids, and other aids such as the use of a neighboring student's paper, are not allowed. The Guidelines specify that students are to do their own work, without the use of crib notes or a dictionary.

For the mathematically oriented reader, another excellent example is provided by the problem situation of trisecting an arbitrary angle. In the figure below, angle ABC is an arbitrary angle (i.e., it is of unspecified size). The goal is to do a geometric construction that divides angle ABC into three equal angles.



Given angle ABC

Sometimes the Guidelines specify that one is only allowed to use a straight edge, compass, and pencil. In that case it can be proven mathematically that the problem cannot be solved. In other cases one is allowed to use a protractor in addition to the other implements. Then the problem is easily solved by measuring the angle, dividing the number of degrees by three, and constructing new angles of the resulting number of degrees. Note that in the latter case the compass is not used, even though it is available. Solving real world problems is sometimes difficult because many resources are available, and often it is not clear which ones to use to solve a particular problem.

For a third example, consider this problem: Teachers in a particular school seem to be using substantial amounts of pirated software. You can investigate the problem situation to clarify the given situation (that pirated software is being used by teachers). You can set a goal, such as reducing the use of pirated software by two-thirds in the first year and decreasing it still more the second year. As a responsible and ethical educational leader, you may have considerable ownership of the problem situation. But what are the guidelines? What types of things can you do that might help achieve the goals?

Brainstorming, individually or in groups, is often used to develop a list of resources (guidelines) or potential activities you might carry out to solve a problem. For example, teacher software piracy might be reduced by an informational program, providing money to buy enough software, threats of dismissal, and so forth. Further exploration would be needed to determine if these options were actually available to the problem solver.

Steps in Problem Solving

In this section we list a sequence of steps that may be followed in attempting to resolve a problem situation. Often we carry out some of the steps quite automatically with little conscious thought. But it can be quite helpful to consciously think about each step in problem situations that seem to be giving us trouble. (Here we are assuming the Ownership condition is satisfied; that is, you are interested in resolving the problem situation.)

1. Work with the problem situation until you have converted it into a well-defined problem; that is, until you have identified and understood the Givens, Goal, and Guidelines. This first step is a creative, higher order thinking process, which often involve considerable knowledge as well as a good sense of values. Two different people, when faced by the same problem situation, may come up with quite different well-defined problems.

2. Select and/or develop a procedure that is designed to solve the problem you have defined. This is an information retrieval and/or creative thinking step. Usually it involves both; computers may be useful in retrieving needed information. (We will discuss the idea of *procedure* more in the next section of this Chapter.)

3. Execute or cause to be executed the steps of the procedure. Sometimes this will be a mechanical, nonthinking activity, where speed and accuracy are desired and computers may be quite useful. (The executions of many mathematical procedures falls into this category.) At other times the execution of a procedure will require the best of truly human skills. (The work of a good psychotherapist falls into this category.)

4. Examine the results produced in Step 3, to determine if the problem you defined in Step 1 has been solved. If it has been solved, go on to Step 5. Otherwise, do one of the following:

    a. Return to Step 3 and recheck your work. People and machines sometimes make mistakes.

    b. Return to Step 2 and determine another approach to solving the problem you have defined.

   c. Return to Step 1 and determine another problem to be solved.

   d. Give up, or seek help from others. The problem might not be solvable, or it might be beyond your abilities, or it might be beyond the efforts you are willing to make at this time.

5. Examine the results produced in Step 3 to determine if the original problem situation has been satisfactorily resolved. If it has, you are done. If it hasn't, do one of the following:

   a. Go to Step 1 and determine another problem to be solved.

   b. Give up, or seek help from others.

Problem solving research suggests that students benefit from learning and practicing the above five-step approach to problem solving. It is applicable over a wide range of disciplines and problem-solving situations. Notice that success is not guaranteed, but that persistence increases the likelihood of success. Note also the personal nature of the five-step approach. Problem solving is a personal thing, and personal values are often central to a problem situation.

What is an Effective Procedure?

When you are able to solve a particular type of problem routinely or automatically, you have developed one or more procedures (algorithms, detailed sets of directions, recipes) for this type of problem. Computer scientists are deeply concerned with developing procedures that tell a computer how to solve a certain category of problem. We will use the phrase *effective procedure* in discussing the idea of a procedure that can be carried out in an automatic, nonthinking, computer-like mode.

More formally, an effective procedure is a detailed, step-by-step set of instructions having the two characteristics:

1. It is designed to solve a specific problem or category of problems.

2. It can be mechanically interpreted and carried out by a specified agent. Here the term "mechanically interpreted" means in a machine-like, nonthinking manner. Computer scientists are interested in situations where the agent is a computer or a computerized machine such as a robot.

Computers are important because they can rapidly, accurately, and inexpensively execute many different procedures. The number of such procedures continues to grow very rapidly through the work of researchers in all disciplines, computer scientists, and computer programmers. Thus, an understanding of the concept of effective procedure is generally considered to be an important part of computer literacy, and it certainly lies at the heart of having a general understanding of roles of computers in problem solving.

Roles of Computers

In this section we briefly examine each of the five steps one might follow in resolving a problem situation. Our intent is to point out roles of computers in each step and to briefly discuss possible curricular implications.

The first step is to understand the problem situation and work toward having a well-defined problem. This is a thinking step , drawing on one's general knowledge as well as specific information about the problem situation. That is, both a broad general education and in-depth knowledge about the specific situation are useful. Many educational leaders argue that a broad liberal arts education is useful in understanding and critically examining the wide range of problem situations one encounters in our society. Values education plays an important role here, since the process of developing a well-defined problem from a problem situation often depends heavily on personal values and views.

Computer-Assisted Learning (CAL) is of growing importance in acquiring education for understanding problem situations. Research evidence strongly supports the contention that students generally learn faster in a CAL environment than they do in a conventional instructional environment. There is strong research evidence that CAL is a cost effective aid to students. The evidence is strongest in the acquisition of factual knowledge, or at the lower-order level of Bloom's taxonomy. Computerized drill and practice works!

The second step is to select and/or develop a solution procedure for the well-defined problem you have produced in the first step. You might select and retrieve a solution procedure from your head.

As an example, the problem might be to determine the number of cubic yards of concrete needed for a patio that is to be 12 feet wide, 15 feet long, and 4 inches thick. A procedure to solve this problem involves conversion of units, multiplication, and division.

S1: Convert 4 inches to feet (by dividing it by 12).

S2: Multiply the three dimensions (each given in feet) to find the number of cubic feet in the patio.

S3: Divide the answer produced in Step 2 by 27, to convert it to cubic yards.

It is important to realize that there can be many different procedures for solving a problem. Here is another approach to solve the patio problem:

S1: Convert all measurements to yards. This involves dividing the measurements given in feet by 3, and dividing the measurements given in inches by 36.

S2: Multiply the three dimensions (each given in yards) to get the number of cubic yards of concrete needed for the patio.

The mental selection and/or development of a solution procedure is a thinking process. One can gain skill in this thinking process through practice. Computers can be used to create practice situations. Many simulations or simulation/games are designed to provide practice in this problem-solving step.

An alternative to retrieving a procedure from your head is to retrieve it from a library, which may contain books, periodicals, films, and so forth. Many libraries have replaced their card catalogs by computerized card catalogs. Moreover, much of the information needed is now stored in computers. One of the defining characteristics of the Information Era we are now in is the growing availability of information and the growing technology to aid in information retrieval. It is clear that computers are very important in retrieving procedures for solving problems. This strongly suggests that all students should learn to make use of these aids to information retrieval.

The third general step in resolving a problem situation is to execute or cause to be executed the procedure from the second step. As we have indicated, some procedures require a "human touch." Others can be executed mechanically, in a nonthinking fashion. A large and rapidly growing number of procedures can be executed by computers or computerized machinery.

If a computer can execute or help execute a procedure, what aspects of this procedure do we want people to learn to do mentally, assisted by pencil and paper, assisted by noncomputerized machinery, or assisted by computerized machinery? This is a very difficult question, and it will challenge our educational system for many years to come. The answer that seems likely to be widely accepted is that we want students to have a reasonable understanding of the problem being solved and the capabilities/limitations of the computerized procedure. We want students to remain in control, but we want them to work with computers rather than in competition with computers.

The fourth and fifth steps in resolving a problem situation require examining the results of your work to determine if you have succeeded. These steps require critical thinking, drawing on your understanding of the initial problem situation and the steps followed in resolving the situation. These are higher-order mental activities.

The research literature on problem solving strongly supports the idea that people get better at problem solving if they study the processes of problem solving, learn to use aids to problem solving, and practice problem solving. This suggests that students should learn to use computers as an aid to problem solving in disciplines for which computers are an useful aid. They should practice solving problems, making use of computers when their use is appropriate to the problems being solved.

Software

In a broad sense, all computer software can be considered as problem-solving software. But when we think of preparing teachers and/or students to deal with computers in schools, problem-solving software tends to fall into three main categories:

1. Programming languages such as assembler, BASIC, C, COBOL, Logo, Pascal and Pilot.
2. Application packages, such as a graphics, spreadsheet, or database package. Some application packages are useful across many disciplines, so we call them "generic." Others are useful in quite limited contexts (such as software for writing music).
3. Simulations/games specifically designed to help students learn specific problem-solving techniques.

There are hundreds of programming languages. In all cases the intent is to make it possible for a human to communicate with a computer. Usually a programming language is designed to meet the needs of a particular category of computer programmers. For example, BASIC was originally designed for college students, COBOL was designed for business data processing programmers, and Pilot was designed for writing Computer-Assisted Instruction materials.

In all cases one uses a programming language to specify procedures to solve certain categories of problems. This is a very important concept. The writing of a computer program to solve a problem requires both a knowledge of a specific programming language and skill in developing procedures to solve problems. The latter is called *procedural thinking* and is generally considered to be an important component of computer literacy. Skill in procedural thinking is independent of any particular programming language. Indeed, one can develop a high level of procedural thinking skill independently of whether computers are available or whether computer programming is used to represent the procedures.

Computer-in-education leaders have not reached consensus as to which students should receive instruction in computer programming, at what grade levels, or using which particular programming language(s). For example, many school systems have decided to provide instruction in Logo to all of their elementary school students. Other districts have decided to include some BASIC in a junior high or middle school computer literacy course required of all students. Still other school districts have decided that computer programming is best left as an elective course, perhaps mainly available to secondary school students who have had a reasonably strong mathematics preparation.

Applications software may be generic (useful over a wide range of disciplines or problem areas) or it may be quite specific to the problems in a particular discipline. A computer graphics package is useful over a wide range of disciplines, while music composition software has much more limited applicability. A trend has begun to emerge, and it seems likely to continue. Many school districts have decided that all students should learn to use a variety of generic applications software. The use of such software will be integrated into the total curriculum. Initial instruction may be in a variety of courses at a variety of grade levels, or it may be concentrated into a single computer literacy course.

At the same time there is growing realization that each discipline has its own applications software. Thus, as students study a discipline at a higher and higher level, they need to receive specific instruction in use of the applications software of the discipline. Thus, two types of computer literacy are emerging. A computer literate student uses generic computer applications software as appropriate in working with problems in every academic area. As a student progresses to higher levels or greater depths in any particular discipline, the student becomes more and more computer literate within that specific discipline. For example, a student who takes college preparation courses in chemistry and physics should be learning quite a bit about applications software specific to the fields of chemistry and physics. Microcomputer-based laboratory (MBL) software falls into this category.

There are many general purpose problem-solving techniques. For example:

1. Plan ahead, anticipating the consequences of proposed actions.
2. A large, complex problem can often be solved by breaking it into several smaller, less complex problems.
3. It is often helpful to draw a picture or map, or in some other manner graphically represent the problem under consideration.
4. It is often helpful to write down the steps you take in an attempt to solve a problem.

Many different simulation/games software packages have been developed to give students practice in particular problem-solving techniques. Research into the value of such software is sparse. The main difficulty seems to be the issue of transfer of learning. For a particular simulation/game, it is evident that students get better as they practice using the software. That is, they get better at applying particular techniques in the context of the simulation/game under consideration. But there appears to be relatively little transfer of the techniques to other problem-solving situations. It seems likely that the teacher plays a very important role in helping to increase such transfer of learning. A teacher can provide a wide variety of examples, suitable to the academic level and interests of a particular student, where the techniques are applicable. A teacher can help encourage students to apply the problem-solving techniques they have studied to the variety of problems they encounter throughout the school day.

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For more information on creative problem solving write to:
Georgia Studies of Creative Behavior
Dept. of Educational Psyhology
The University of Georgia
Athens, GA 30602

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INITIATING/PLANNING AN INSERVICE

3.1

Preliminary Planning and Activities

This section consists of some general ideas followed by the project staff in setting up the workshops. Although some of the ideas are useful primarily to people who are working in a relatively formal environment such as a funded project, others apply to any inservice activity.

Many inservices are open to all educators in a district or region, perhaps subject only to certain prerequisites. But research on effective inservice points to the value of peer support within a school or department. Thus, there is considerable merit in having a number of participants from a single school. The NSF project set guidelines of having at least 3-5 or more participants from each school, including a school administrator. While it was not always possible to adhere to these guidelines, they served as an aid in the participant screening process.

Needs Assessment

The starting point for planning an inservice is to determine the need(s) that will be addressed by the inservice. (That is, what educational problem is being attacked through the inservice?) Chapter 1.1 discusses some of the needs that an inservice might address. The question is, how are needs determined?

Ideally, a school district would have a carefully developed long-range plan for instructional use of computers. Detailed information on the development of such a plan is given in Moursund and Ricketts (1988). The appropriate development of such a long-range plan involves participation by all of the stake holders. Thus, teachers, school administrators, parents, etc., all have ample opportunity to provide input.

A long-range plan calls for certain actions to be taken. Generally, these actions will include acquisition of computer facilities, acquisition or development of software, courseware, and curriculum materials, and *staff development*. That is, the process of developing a long-range plan can play a major role in doing a needs assessment for a computer inservice. One merely points to the long-range plan and says "We need to do this particular inservice because of the key role it plays in implementation of the plan."

There are, of course, other approaches to needs assessment. And even if one has a well done long-range plan, these other approaches are useful and should be followed. Generally speaking, a needs assessment should be done using both a bottom up and a top down approach. The bottom up approach is to obtain information from the people who are to be inserviced. The top down approach is to obtain information from the administrators of the people who are to be inserviced. Such information can be obtained by personal interviews, use of questionnaires, informal conversations, etc. Part 5 of this Notebook contains some needs assessment instrumentation.

The needs assessment will answer a variety of questions such as:

1. What are the demographics of the group of potential participants in the inservice?
2. What level of interest is displayed by the group of possible participants?
3. What are suitable meeting times, places, length of sessions, and number of sessions for the potential participants?
4. What incentives, such as college credit, release time, improved access to computers in their schools and classrooms, etc. are needed to secure there will be an appropriate number of participants?
5. What is the level of support from the administrators of the potential participants? Does this level of support include release time for teachers, appropriate materials, appropriate staff support to develop and conduct the inservice, etc? Does it include making appropriate computer facilities available to the participants in their schools and classrooms during and after the inservice? Does it include actually participating in some or all of the inservice sessions themselves?

Staffing

Most people who organize and present inservices are trained and experienced teachers. But facilitating an inservice is quite a bit different from teaching a class of precollege or college students. Also, the inservice participants will all be educators themselves. Educators expect that the inservices they participate in will be models of excellence. They are not very tolerant of poor organization and teaching. Most teachers find that teaching teachers is much more difficult than teaching other groups of students.

We have two recommendations. *First*, don't attempt to do a hands-on inservice (such as discussed in this Notebook) without an assistant. Your assistant may be someone you are helping to train as an inservice facilitator or a computer coordinator from one of the schools participating in the inservice. Once participants get into a hands-on mode, there will be many more questions than a single facilitator can handle. Or course, having participants work in pairs will help some. Emphasize that participants are to work quite hard to discover the answers to their questions before they seek help from the workshop facilitator or assistant.

Second, plan to spend at least 8-12 hours preparing for each two-hour inservice. Many teachers are used to planning a whole day's teaching in an hour or so. But a staff development workshop is quite different. Here you will be working with your peers, and you want to do an excellent job. Here also you are doing something new -- you have not offered the workshop a number of times before. *It will take a lot of hard work to be adequately prepared to facilitate the workshop sessions.*

Some Initial Ideas

Let's assume you have decided to conduct an inservice and that you have a general topic and audience in mind. You do a needs assessment and conclude both that you will be able to obtain appropriate participants and that you will have appropriate administrative support. You have a staff (it might be only a part-time secretary, a volunteer, or members of a district computer committee) who will be involved in the overall planning and implementation process. You have selected an assistant who will help during the inservice presentations. You have a good idea of how the inservice will contribute to accomplishing the district's overall plans for computers in education.

The following list of ideas may help you as you continue the planning and development of the inservice.

1. Meet with your staff early and often. Have them participate in the overall planning process as much as possible. This helps to keep them informed (so they can respond to telephone inquires when you are not available, for example) and increases their "ownership" in the overall task.

2. Establish guidelines for selecting the schools and individuals who will participate. Check these guidelines with the funding agency or group responsible for making the inservice possible. If you are not the computer coordinator for the region to receive inservice, check with the computer coordinator.

3. Communicate with the potential participating schools and individuals. This may be done via a combination of mail (regular and electronic), announcements in newsletters, phone calls, and direct contact. Indicate generally the desired nature of school and individual participants, and indicate where and when an information meeting will be held.

4. Prepare for and conduct the information meeting. You will want to have a handout containing key information that possible individual and school participants need to know, which may include appropriate application forms. Hold the informational meeting early, so that possible participants from each school will have time to have an in-school meeting to decide if they will participate.

5. If you are giving university credit to the participants, make sure you have everything coordinated with the university or college as well as the school district(s). This process can take some time, so begin early.

6. Your inservice will use of a variety of software. You will need multiple copies and/or permission from publishers to do multiple loading. Make sure that you begin the process of obtaining the software and/or permissions early enough so that this task is completed well before the inservice is scheduled to begin.

   The choice of software can be a major decision. Should you use software readily available to teachers, or should you use the "latest and greatest?" An inservice must be grounded in reality. Thus, much of the software used should be software to which teachers have easy access. But an inservice should also be forward looking. Thus, it is appropriate to use some software that may be new to teachers in your school or district.

   To a large extent, the NSF project used software from the Minnesota Educational Computing Consortium (MECC). This was done because such software is in wide use throughout North America and because it was available in the school district where the inservices were being conducted. However, we also obtained multiple copies of some software on loan from certain vendors, and we obtained permission to do multiple loading from certain other vendors. Our experience was that vendors are very supportive of staff development efforts.

7. Your inservice may make use of print materials that will need to be ordered from publishing companies or reproduced. It can easily take a month to obtain print materials from a publishing company, so begin this process well in advance of the starting date for your inservice.

8. Think about where and when the inservices are to be conducted. From the point of view of the inservice organizer, it is easiest to conduct all inservices at one central site, and to hold them at a time that "seems" convenient to the organizer. However, participants may gain more ownership and overall involvement if the inservices are conducted in their schools. This involves holding inservices at a number of different sites with varying equipment facilities. It involves holding inservices at a time that the potential participants have indicated fits their needs.

Miscellaneous Suggestions to Inservice Facilitators

1. At the first meeting of the inservice, be well organized. Have name tags available, appropriate refreshments, etc. Be efficient and business-like. If appropriate, provide each participant with a list of the names, addresses, and phone numbers of the participants and the facilitators.

2. At the first meeting of the inservice you will most likely want to have a number of things to hand out. These might include:

    a. A notebook for participants to keep materials in, with colored paper or dividers to separate the lessons.

    b. The types of materials illustrated in this notebook. (Some inservice facilitators prefer to hand out all materials during the first session, while others prefer to hand out each session's materials at the start of that session.)

    c. Other print materials, such as books, that participants will need to read during the inservice.

    d. Some software, if it is appropriate. For example, there may be some excellent public domain software that is suitable for participants in the inservice. Participants like to receive free materials.

    e. A syllabus for the inservice.

3. Much of the material you hand out may be forms that you want participants to write on during the inservices. If so, make sure participants know that extra copies of these pages in the handout can be "ordered" from you so that they feel free to write on them during the sessions. Have a form available to them, so they can order copies as needed, or just provide them extra copies in an automatic fashion.

4. The computer is a powerful tool and a powerful change agent in education. Both the overall educational system and individual educators are (in general) resistant to change. The inservice facilitator should deal openly with change processes and resistance to change. This should be a reoccurring theme in the debriefing at the end of each activity. Spend some time thinking about educational change. How do you feel in your role as a facilitator of change?

5. Student / teacher modes. The style of inservice described in this Notebook has the participants sometimes play the role of "students" and other times play the role of "teachers." Make the participants aware that at times they will be students and at other times teachers during the inservice sessions, and why the inservice is designed in this way. This switching of modes can be confusing, so make it clear when you are having participants switch roles.

6. The style of inservice described in this Notebook is heavily oriented toward discovery based learning. Be aware that relatively few teachers are comfortable with discovery based learning. Think about why discovery based learning is particularly appropriate in computer education and in this inservice. Raise this as a topic for discussion quite early in the inservice, and raise it several additional times during later inservice sessions.

7. Transfer of learning is a very important idea in computer inservices. The goal is that participants will take ideas from the inservice and implement them in their classrooms. Raise this as a topic for discussion during the first inservice session and bring it up again at subsequent sessions. It is quite appropriate to ask in the second and subsequent sessions "Would one of you please share with us some classroom uses you made this week of the ideas that we covered in the last session?" Do everything you can to encourage such immediate implementation and the sharing of successful implementations.

8. Keep in mind that problem solving is a central and unifying theme in the inservice and is the main reason why computers are coming into schools.

   a. The computer-as-a-tool is essentially the computer as an aid to problem solving. Problem solving should be a central theme in every activity and in every debriefing.

   b. Many of the changes that may occur as computers come into schools are changes that could/should occur even without computers. A typical example is increased emphasis on problem solving in math and decreased emphasis on rote computation. Another example is increased emphasis on the overall writing process (process writing) and less emphasis on the mechanics of writing, such as spelling and grammar.

9. Preparation time. (Here we are repeating some ideas given earlier in this chapter, because they are particularly important.) The novice inservice facilitator may wonder how much work is involved in preparing to facilitate a sequence of inservice sessions. Of course, a lot depends on the standards the person sets. Also, the time depends heavily on the overall knowledge of computers, computers in education, the subject discipline of the teachers to be trained, and the software to be used. The experiences of the NSF graduate assistants who did almost all of the presentations during this project have shown that even a highly qualified inservice facilitator can easily spend 8-12 hours preparing for a two-hour inservice. (*Note*: It doesn't take nearly this long to prepare for subsequent presentations of the same inservice.) Access to materials such as those in this Notebook can decrease preparation time somewhat and can add to the overall quality of an inservice. But to a very large extent, the quality of an inservice depends on the quality, experience, and preparation of the facilitator.

References

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3.2

Sample Timeline Outline

The final format of the NSF inservice sessions discussed in this Notebook was a sequence of two hour sessions. The sessions were held immediately after school, typically from 3:30-5:30 or 4:00-6:00 in the afternoon, one day per week.

Through careful thought, trial and error, and experience, we gradually developed a Sample Timeline for the organization of a two hour session. In essence, this Sample Timeline consists of a model for a one hour session, and the model is followed twice for a two hour session. This way of building longer sessions from a one hour session can be further extended to still longer inservice sessions.

The outline given below suggests specific amounts of time for the various parts of an inservice session. However, flexibility is important. The actual time spent on any given activity will depend on the activity, the facilitator, and the participants.

Minutes allotted	Activity
10 Minutes	Starting activity. Have participants either work on an off machine activity or on the computers with software that is fairly self-explanatory. Make use of an appropriate Performance Aid.
5 Minutes	Debriefing of the above activity.
25-35 Minutes	First major activity for the session. This is time for the participants to be on the computer. It can be a more in-depth continuation of the starting activity, or it can be a new piece of software.
10-15 Minutes	Debriefing of the above activity.
10 Minutes	A short break for stretching, coffee, cookies, other refreshments, and informal conversations. Generally speaking, there is never enough time to accomplish the aims of an inservice program. Don't let the break time stretch too much!
30-35 Minutes	Second major activity. Again, participants will be using the computer in most such activities. However, sometimes off machine activities are quite appropriate.
10-15 Minutes	Debriefing of the second major activity.
10 Minutes	Closure. Summarize what was accomplished during the day; any additional comments from the participants or yourself; details of the next meeting.

This general outline is only meant to serve as a starting point for organizing a two-hour session. There may be certain sessions where the debriefing and discussion is of more important than hands-on time. In those cases the facilitator should adjust the schedule as necessary. In other cases an off-machine activity may be more appropriate than a hands-on activity.

A key concept in the CI^3 model is a discovery-oriented approach. Most inservice facilitators are quite used to delivering lectures that cover a given body of material. But the amount of straight lecture time in a two-hour session such as outlined above should probably be less than ten minutes!

Rather than lecture, the inservice facilitator facilitates. Participants spend the bulk of their time in two modes. The first is a hands-on mode, usually working in groups of two at a machine. This is a learn-by-doing environment. Participants are encouraged to answer their own questions by a combination of trial and error, reading the Performance Aids and other handouts, and asking each other. When the inservice facilitator must intervene, it should be as a facilitator rather than as an answer provider.

The second major participant mode is group discussion, sometimes in small groups and sometimes in a whole-class group. Many teachers have had relatively little experience in facilitating small-group and large-group discussions. (A good way to gain experience is by working with a group of educators. This is because once a facilitator gets educators started talking, it is hard to get them to stop!) A good rule of thumb is that the facilitator should talk less than half of the time during a group discussion.

The group discussion debriefing sessions must lead to discovery or reiteration of the major points covered. Thus, the facilitator must have these points in mind. As participants make comments that relate to the major points, the facilitator must seize these opportunities to make sure that these points have been discovered and comprehended by all participants. Initially, many inservice facilitators find that this is harder to do than to just delivering a straight lecture. But, with practice, it becomes an enjoyable and relatively easy mode of instruction.

EIGHT-SESSION
MATHEMATICS INSERVICE

4.0
Software Bibliography

Developers of an inservice should give careful thought to whether they want to base their inservice sessions on the "latest and greatest" software, or software that is more apt to be available to teachers. Ideally, essentially all of the software used in an inservice would then be immediately available for participants to use in their classrooms. Generally speaking, it is more important to achieve this objective than to make use of the "latest and greatest" software that is on the market. This assumes, of course, that the software being used in the inservice is of acceptable and useful quality.

There is a great deal of software that would be useful in a computer inservice for secondary school math teachers. This section lists most of the software used when this NSF Math Inservice was conducted during the 1986-87 academic year. It is advisable to check with the producer; prices, as well as availability, tend to change rapidly.

Apple Computer, Inc. 20525 Mariani Ave., Cupertino, CA 95014; 408/996-1010.

Apple Presents AppleWorks
A hands-on tutorial for the AppleWorks program.
Free with purchase of AppleWorks--Apple II (128K recommended).

AppleWorks **Grades 5-College**
A very widely used integrated word processing, spreadsheet and database program.
$175--Apple II (128K recommended). Lab packs are available at a substantial savings per copy of the software.

Broderbund Software, 17 Paul Drive, San Rafael, CA 94903-2101; (415) 479-1700.

Geometry **Grades 9-College**
An interactive geometry program that follows the traditional geometry curriculum. It includes over 450 problems and proofs.
$99.95--MacIntosh 512K and up.

EduSoft, P.O. Box 2560-OG, Berkeley, CA 94702; 415/548-2304.

SuperPlot **Grades 8-College**
Graphing software that quickly graphs any polynomial, trigonometric, logarithmic, or exponential function. Up to five functions may be displayed on the screen at the same time, allowing comparisons. The user can scroll functions left, right, up, or down to investigate key areas of interest. One can also zoom in or out on either axis.
$49.95--Apple IIe/c.

The Learning Company, 545 Middlefield Road, Menlo Park, CA 94025-9968; 800/852-2255.

Gertrude's Puzzles **Grades 1-6**
Problem-solving software that builds basic thinking skills. An exploratory game in which students solve puzzles by using the attributes of the playing pieces on the screen.
$44.95--Apple II, Commodore, IBM PC (color monitor required).

Rocky's Boots **Grades 2-College**
Problem-solving and logic-forming software. The game format allows players to move from room to room as they learn what pieces do and how to connect them. There are six sections, each with various rooms of progressive difficulty.
$49.95--Apple II, Commodore, IBM PC, Tandy.

MECC, 3490 Lexington Ave. N., St. Paul, MN 55126; 612/481-3500.

MECC Graph **Grades 3-12**
An easy-to-use, flexible aid for graphing small amounts of data. One can graph name-number and number-pair data (up to 3 sets). Name-number data can be graphed as a line, bar, or pie graph. User can change data and adjust scales of graphs.
$49--Apple 64K.

MECC Graphing Primer **Grades 3-12**
The five activities: Line Games, Bar Games, Tell the Story, Quick Review, and Find a Fact provide students with an interactive review of basic graphing concepts. Emphasizes skills of analyzing line, bar, and pie graphs. Presumes some previous instruction in graphing terminology and instruction. Each program involves students in the process of analyzing a graph.
$39--Apple 64K.

MECC Mathematics Volume 1 - Graphing, Logic and Equations
Grades 6-12
Eight programs focus on central concepts of secondary math. Versatile graphing utilities enable students to explore algebraic and geometric concepts, and games provide practice in thinking logically and in applying concepts of coordinate geometry to various problem simulations.
$29--Apple 48K.

Mind Puzzles **Grades 6-10**
Varied activities involving mazes, patterns, and arrays. Students must use logical thinking to solve problems.
$49--Apple 48K.

Sunburst Communications, 39 Washington Ave., Pleasantville, NY 14850; 800/431-1934

Green Globs and Graphing Equations **Grades 8-College**
Four programs for graphing equations. Equation Plotter plots conic equations and general functions. Green Globs has two game levels, both displaying 13 green globs scattered randomly over a set of coordinate axes. Students determine and enter equations for the graphs that will hit as many of the green globs as possible. Linear and Quadratic Graphs draws a graph and the student must write the equation for that graph. The student's equation is also graphed on the screen in a different color. Tracker is a game in which students must locate linear and quadratic graphs hidden in a coordinate plane and determine their equations. $60--Apple IIe/c/+/GS 48K.

High Wire Logic **Grades 5-9**

Students are watching a high wire act with balancing objects. Some of the objects fall into the net. Students earn points by writing as many rules as possible using and/or/exclusive or to describe the objects still remaining on the wire.
$59--Apple IIe/c/+/GS 48K (color monitor required).

Teasers by Tobbs **Grades 4-10**

Two programs give students practice in logically solving addition and multiplication problems. The games are in the shape of an addition or multiplication grid. The grid presents a series of math problems, each missing a number. Students decide which number can't be, might be, or must be the correct solution.
$59--Apple, Atari, TRS-80, IBM, PC, Commodore.

The Factory **Grades 4-12**

The Factory is a problem-solving visualization game. It is designed to teach several strategies: working backwards, analyzing a process, determining a sequence, applying creativity, visual reasoning, and rotation. There are three levels: experimentation, making a product, and challenges.
$59--Apple, Atari, Commodore, TRS-80, IBM PC.

The Super Factory **Grades 4-12**

Brings three-dimensional images to the computer screen in the form of a cube whose six faces contain varying objects with varying orientations. Students are taught problem-solving strategies and gain skill in spacial visualization as they research and design products and challenge each other. Different levels of difficulty encourage students to think logically.
$59--Apple II/e/c/GS.

The Geometric PreSupposer **Grades 5-10**

This piece of software provides a solid foundation for geometry by introducing simple constructions that can be made with a straight edge and compass. Students can measure lengths, angles, areas, and circumference, and then experiment with mathematical combinations of these measurements.
$99--Apple IIe/c/+/GS 64K.

The Geometric Supposer-Circles **Grades 8-12**

This piece of software provides students with a flexible tool that allows them to investigate the properties of a circle. After choosing a construction on a circle, students can easily change the scale and repeat the construction on new circles.
$99--Apple IIe/c/GS 64K.

The Geometric Supposer-Quadrilaterals **Grades 8-12**

Students can make any construction they wish on any quadrilateral and the program records that construction as a procedure that can be executed on any other quadrilateral.. The user can explore whether the consequences of a given construction on a given quadrilateral are dependent on some particular property of that quadrilateral or if the result can be generalized.
$99--Apple IIe/c/GS 64K.

The Geometric Supposer-Triangles **Grades 6-12**

This piece of software allows the user to make any construction on a triangle and records that construction as a procedure that can be executed with any type of triangle.
$99--Apple IIe/c/GS 64K.

Gentleware Corporation, 2509 Saginaw Trail, Maitland, FL 32751.

Formula Vision **Grades 5-12**

An easy-to-use spreadsheet, designed specifically for a low level introduction to the idea of a spreadsheet and its possible uses in working with formulas. There are only 15 cells in this spreadsheet, which fills the Apple screen. Each cell has three categories: name, numerical unit, and unit of measure. The purchase price is for a classroom site license.
$29.95--Apple II+/e/c.

Wadsworth Electronic Publishing Co., 8 Davis Drive, Belmont, CA 94002.

Algebra Arcade **Grades 8-12**

A graphing program in game format. The object is to type in an equation that will hit as many of the "algebroids" as possible. The program keeps score. Various equations can be typed in.
$49.95--Apple IIe/+, IBM PC, Commodore 64, Atari 800.

4.1
SESSION 1: GRAPHING TO REPRESENT DATA

4.1.1 Narrative Overview

Most of the eight math sessions presented in this Notebook are designed so that participants spend about half of their time in a hands-on mode, with the remaining time spent in small group and whole group discussions. We emphasize allowing participants to "discover" key ideas. There is relatively little time devoted to formal lecture.

This first session is unusual, because substantially less than half of the time is spent in a hands-on mode. Although it is desirable to include maximum hands-on time in each meeting, during the first session it is desirable to help the participants and staff get to know each other and introduce the overall philosophy of the CI^3 model.

Each of the eight sessions presented in this part of the book is designed to be two hours (or more) in length. If sessions are longer than two hours, the extra time in the first session can be used for additional hands-on activities. Several additional activities are suggested. That is, each of the eight sessions described in this book contains more than enough materials for two hours.

In the first session participants use the computer and *MECC Graph*, a very easy graphing program that can be used to produce line, bar, and circle graphs. (Note: *MECC Graph* was selected because of its availability in the school district where the inservice was held, with copies provided to all participants under terms of the licensing agreement. Other graphics software can serve the same purposes. Select software that is available to participants in their schools.)

MECC Graph can be used from the elementary level through high school. Some high school math teachers may feel that this program is too simple and limited for their students. If this happens, you may want to discuss why it is desirable for teachers of more advanced courses to know what students are learning in the more elementary courses.

The CI^3 model focuses on discovery-based learning, which occurs through participants discussing the activities as they work together (typically in pairs) on the computer or in debriefing at the end of each hands-on activity. In debriefing, questions are encouraged and key ideas are "teased out." The inservice facilitator must have a clear idea of what key ideas are to be "discovered" by the participants.

Sometimes participants will not make observations or ask questions that lead to the discovery of key ideas. In such cases the inservice facilitator may need to ask leading questions. Some sample questions that can be raised to encourage discussion include:

1. What grade levels might find this software appropriate? (Can it be used in grade school? Is it too simple and limited for high school use?)

2. If students entering the courses you teach already have a good working knowledge of this graphics software, how will it affect your courses?

3. As computers and graphics software become more readily available to students, how much "by-hand" graphing capabilities do you feel students should acquire?

4. What types of math problems can be solved by use of this graphics software? (Start to explore the difference between being able to use a tool and being able to solve problems using the tool.)

5. If you are having students use graphics software in your class, how might you handle the testing issue? (Do a probe to see if any of the participants have experience in giving students access to computers during tests. You might make an analogy with the use of calculators. There are now handheld calculators that can graph. For example, Casio sells a quite powerful graphing calculator for about $75.)

In this first session we introduce a model of mathematical problem solving. It contains five components:

1. Understand the (real world) problem.
2. Develop a mathematical model of the problem so you now have a "pure" mathematics problem.
3. Solve the mathematics problem.
4. Translate the results back into a statement about·the real world; that is, do a mathematical unmodeling process.
5. Compare the results with the original problem. Has the original problem been solved?

This mathematical problem-solving model will be brought up in nearly every session. The computer is more useful in Step Three than in the other steps. But most mathematics instruction time is also spent on Step Three. This is getting at the heart of how computers might affect mathematics education. Mathematics education leaders are strongly supportive of teaching students to make use of calculators and computers to help do step three, and to spend less time teaching students how to do this step using by-hand methods.

Many mathematics educators support the idea of discovery-based learning. Computers can be used to add another dimension to discovery-oriented instruction. However, teachers are always challenged by the large amount of curriculum material that must be covered. The idea of spending mathematics class time teaching students to use computers further complicates the issue. Such difficulties should be discussed openly as they are brought up by the participants.

Traditional college and university courses typically assign a substantial amount of homework between class sessions. Because most of the workshop participants are already working more than full time in their teaching job, each facilitator must decide the nature and extent of homework assigned to participants between sessions.

For the NSF inservices, we chose to incorporate a "Game of the Week" as part of the homework. Each game was designed to be both academically relevant and fun. Most could be completed in a modest amount of time, a result consistent with our decision to keep required homework to a minimum.

The title *Game of the Week* was designed to help participants think of the assignment as an opportunity to do some creative thinking and make effective use of this inservice. There are no "winners" as such, but those who do the exercises will gain greater insight into using computers in their classroom. The games also encourage participants to think about key issues and contemplate some computer-related changes in mathematics education.

The Weekly Log is another approach to homework. We required participants to fill out a log sheet each week, indicating uses they have made of computers and related ideas from the inservice. Related to this is that each weekly session included materials that participants could use with their students. In subsequent sessions some time was made available to discuss the successes and failures that participants had as they tried out these materials with their students.

4.1.2 Script

For each of the eight sessions we provide both a detailed script and a timeline. We suggest that you study the script carefully. From it, develop your own timeline containing an outline of what you actually intend to cover in a session. (A script contains more detail than you will need when actually facilitating an inservice session. Most facilitators would find it somewhat confusing to have such a detailed script in front of them when actually doing an inservice. But the detailed script is a help in preparing for an inservice session.) The next section of the notebook contains a sample timeline used at one of the NSF inservice sessions. It was built from the script that follows.

Each script contains enough materials for substantially more than a two-hour inservice. Thus, the facilitator will need to select a subset to present in the time available. (Most facilitators also will incorporate a number of their own ideas and materials.)

The reader will note that this first script is much more detailed than later scripts. It is important to be considerably over-prepared for the first inservice session. Once the inservice series is off to a good start, you will find that less detailed preparation is necessary.

Theme

Organizing data

Objectives

1. Give an overview of the inservice goals.
2. Represent information in graph form using software.
3. Compare line, bar, pie and pictograph representations.
4. Graph real-world information.
5. Identify the impact of equation graphers on the curriculum.

Abbreviations

Readers of this script and subsequent scripts should note the following abbreviations:

(HO)	Handout
(LP)	Lesson Plan
(OV)	Overhead Transparency/Slide
(PA)	Performance Aid (A "crib sheet" set of notes to aid a person in using a piece of software.)
(WS)	Worksheet

Materials

Software
MECC Graph with
Lucy Van Pelt File
Super Plot
Note: Use of *Super Plot* may be delayed until the second session.

Handouts
(LP) Lucy Van Pelt

(OV) MECC Graph
(PA) MECC Graph
(HO) Our Day Pie Graph
(HO) Predict and Graph
(HO) Graph Probs
Names and schools of all participants (to be prepared by presenter)

Refreshments

Resources

Overhead projector

Setup
before
starting
(PA) *MECC Graph*

Prior to participants' arrival, load each computer with:
MECC Graph
- Select the bar graph
- Use a file of data that represents how Lucy Van Pelt spends her time.

You will want to create a Lucy Van Pelt file that seems suitable to the inservice situation. This is a file that can be graphed by *MECC Graph* and which contains data on how Lucy spends her 24 hour day. Suitable items might include Beauty (4 hours), Eating (2 hours),School (4 hours), TV (3 hours), Being Nasty (1 hour), Sleeping (8 hours), and Free Time (2 hours).

Have a large screen monitor or projector available for demonstrations.

Start on time

As participants arrive, give them name tags, form them into pairs, and put them on computers. That is, as soon as two people arrive, get them started on the computer. As more people arrive, pair them up and get them started. Make it clear that the inservice starts on time and that there is something useful to be doing as soon as one arrives.

10 Minutes
MECC Graph

Everything begins on time with a hands-on activity.
Participants work in pairs and follow instructions written on overhead or in a handout.

Overhead

Instructions:

OV #1 MECC Graph
or
Blackboard
or
Handout

Predict the bar graph and then:

Press G	for the graph
Press Q	to select a different graph
Select Pie	to see the Pie graph
Press Q	to select a different graph
Select Line	to see the representation in Line

(√ understanding)

Leave the most appropriate representation on the screen.
(This could be done on a worksheet, instead of using an overhead, along with discussion questions.)

Discussion
5 Minutes

Pull the focus away from the computer to the presenter. This method of starting immediately will be modus operandi throughout the inservice series. Whole group discussion comparing the different representations. Determine which graphing form is most appropriate for this problem.

Introductions
30-40 Minutes

Purpose: To introduce the inservice facilitators and give a little information about their backgrounds. Participant introductions. This should include name, school, grades/subjects taught, or administrative position.

Overall presentation:
- There will be a problem-solving theme in all of the sessions.
- Steps in math problem-solving. (See the diagram in the Game of the Week). Note that relatively little school time is spent on modeling, unmodeling, and checking to see if the real world problem is solved.
- Knowledge of math (computation) will not decrease because of computers, but the emphasis on computation should, with more time spent on modeling.

Break
10 Minutes

Refreshments.
(It is all right to have beverages available for participants when they first arrive at an inservice. But the main "goodies" should not be made available until the mid session break.)

Demonstration

Purpose: Introduce editing.

Lucy Van Pelt
5 Minutes

The file does not include an important part of Lucy's day--
the amount of time spent crabbing. So, edit the file and add crabbiness. What happens to the total number of hours? Participants determine which hours are changed. Predict the percents on the pie graph before graphing.

Activity

Purpose: Practice editing and predicting results.

(WS) Day in your life
10 Minutes

Fill in personal information on the worksheet and add that to the file on the computer. Do two pie graphs. Early finishers can also view the data in bar graph form or practice other ideas.

Discussion
5 Minutes

Have participants think about the range of possibilities for using a piece of software like *MECC Graph*. What teachers do at one level affects teachers at other levels.

Activity
10 Minutes
(Omit if time is a problem.)

Purpose: Concrete kinesthetic graphing example, which bridges the more abstract computer graphing activities. Participants will form a bar graph (really a pictograph) using their own bodies, based upon eye color. From the bar graph have the participants form a pie graph. (Do not give instructions on how to do it, let them find a solution. *Note*: one way is for everyone with the same color eyes to hold hands and then all the colors form a circle.)

Discussion

What insights did they gain doing this versus using the computer?
What other types of information could be graphed this way?

Discuss three learning stages:
1. Concrete
2. Pictorial
3. Abstract

This concrete kinesthetic bridge activity can be used in the classroom. The order of activities in the inservice was done backwards (computer first) because of participants' skills. The computer is kinesthetic, touching the keys is sensory input, but most of the thinking is abstract with some pictorial. Bridges must be developed and traversed between on-line and off-line activities.

Demonstration

Purpose: Ease of changing the scale of a graph.

10 Minutes
MECC Graph
Newspaper Graphs

How the scale of a graph can affect the understanding of the information. Presenter will demonstrate a bar graph on *MECC Graph*. This graph can be from a newspaper article or one of the existing MECC graphs. Then change the scale on the graph. Increase the scale. What is the new impression of the graphed data? Discussion can revolve around the use of graphs to bias information presentations.

Activity

(HO) Equations
SuperPlot

(Omit if time is
a problem.)
10 Minutes

Purpose: Introduction to graphing equations.

Participants use handout and predict the graphs of the equations.
Presenter then demonstrates *SuperPlot* using the first graph on the worksheet.
Say out loud the keystrokes. Use the exact words necessary to obtain the graph. Use few, if any, other words.
Participants go and check their graphs by using *SuperPlot* at their machines. Record results in Column 2.

√ Understanding

Presenter goes down the list of equations and the participants graph the results in the air without looking at what they recorded from the computer.

Activity
(HO) Graph Probs
(Omit this section
if time is a problem.)

Extension to using *SuperPlot:* Use (HO) Graph Probs.

Discussion
5 Minutes
(Omit if time is
a problem.)

This concrete approach allows the presenter to check for understanding and introduces a new activity for the participants to use in their classes. Discuss implications of using the computer as a graphing tool. Does this change the order or the way in which concepts can be taught? (See NCTM reference on Inverted Curriculum.) How young should students understand graphs? Middle school teachers may feel that this has no effect on what they teach. It is important that they understand the tools that their students will be using in the future. This can affect the skills their students will need.

Debrief

30-40 Minutes

Purpose: To debrief the last exercise and the overall first session.

Discuss the format of the session.
Explain the sequence of future sessions.
Prepare teachers for their roles in planning and sharing what they have learned with others in their school.

Some possible questions/ideas for discussion.

1. What did you enjoy most in today's session?
2. What one idea will you take back to your school and try?
3. What will you share? It does not have to be a computer idea, it could be a non-computer activity.
4. What did you gain from working in groups? How do you set up groups when you use computers with students?
5. Which behavior or management techniques can work in your classrooms?
6. Off-computer activities are as important as computer activities. How can you modify today's off-computer activities to use with your students?
7. When were a variety of auditory, visual and kinesthetic avenues used in today's session?
8. Which ideas require specific computer knowledge, and which depend primarily on general knowledge math teachers already possess?

Game of the Week

Look at three different courses (or three different parts of on course), and evaluate a unit to see how much time is spent teaching the vertical as opposed to the horizontal lines in our mathematical model which is in the Game of the Week (HO).

Project

Project reports will be presented during the last session. You will want to get participants started thinking about projects right away. You might indicate that:

- The last session will be one in which individuals or groups present projects.
- The ideas are left to the participants.
- The projects may be for their own classroom (e.g., planning a scope and sequence that can be used across grades; inservice ideas for their own staffs, etc.).

Weekly Logs

Logs are to be filled out each week in order to help participants keep track of their own computer-related activities. Information to keep track of in Weekly Log might include:

- Software used or previewed
- Noncomputer activities used
- Teachers with whom they have shared information
- Project ideas
- Questions to ask presenters.
- Notes to self that one might want to save and review after the inservice is over.

Closure

If there is time, let teachers from each school form groups. Their task will be to begin to discuss what they can do to help people in their school. What are the needs at their school? How can information best be shared? This is not a time to complain, but a time to be pragmatic and look at how things can be improved. Participants may wish to begin discussing project ideas that could involve the overall school math curriculum.

Bye-Bye

Make teachers aware of how much they have covered in a short period of time.
Encourage them to incubate ideas.
Thank them for their participation.
The closure might also contain a brief preview of coming attractions.

Think Ahead

Remind participants to fill out their logs. Let them know where the next meeting will take place. Discuss who will provide refreshments, if refreshments are to be provided by the participants.

Evaluation (Indicators)

How well did the inservice go?
At the end of each inservice session you will want to debrief the overall session along with any assistants. If you have worked alone, sit quietly for a few minutes and debrief it by yourself. The following list can be used to help in the debriefing. We will not repeat this list; it can be used each time.

1. Did participants seem to have fun?
2. Did each participant find one idea to take back and use?
3. Did participants work in groups?
4. How did the demonstrations go?
5. Was the desired behavior modeled?
6. How did the off-computer activities go?
7. Did you vary the auditory, visual and kinesthetic input?
8. Did you acknowledge the valuable skills and knowledge participants brought to the inservice?
9. Were you satisfied with how well you did?

4.1.3 Timeline

This is a sample timeline for a particular implementation of the two-hour inservice described in the previous section. The general idea is that one first develops a detailed lesson plan such as given in the previous section. Then one develops a simple and specific timeline such as is given here, and one uses it to do the actual presentations. Have computers loaded with *MECC Graph* and have the Lucy Van Pelt file on the disk for easy access.

0:00-0:13	Hand out notebooks and the packet of handouts for this session as participants arrive. Get the participants on the computers in groups of two as soon as possible. Each person should have the Predict the Bar Graph sheet in their packet and should follow the instructions.
0:13-0:23	**Discussion/debrief.** Move participants off the computers and start discussing the first computer activity. Train participants to move from a computer activity to a discussion activity -- for example, train them to turn off their computer monitors when told to do so.
0:23-1:05	**Introductions.** Facilitator(s) and participants should introduce themselves. [*Note the handout with names and phone numbers (10-12 min.)*] Overall presentation • Problem-solving theme • Mathematical modeling • Changes in the math curriculum (15-20 min.) Format of this presentation and others • Outline of this session • A little different because of introductions. We will spend more time on the computers in future sessions. (5 min.)
1:05-1:15	**Break.**
1:15-1:20	Demonstration of editing on large screen. Participants should verbally give changes and predictions.
1:20-1:30	Fill in **Day in Your Life** worksheet, enter this data into the computer, and graph it.
1:30-1:35	**Discussion.** What good is this? What do we expect students to learn from a piece of software like this? What can be graphed in this manner?
1:35-1:45	**Demonstration.** Change the scale on a graph and see what happens. Should students be aware of the ability of people to skew graphs? Give some real life examples in class.
1:45-2:00	**Closure.** • Discuss format of the session again (more computer time in the future). • Explain sequence of sessions and where they will be held. • Prepare teachers for their roles in planning and sharing with others. • Explain **Game of the Week** and distribute the first game.

- Review the **Log Sheet** and remind them to fill them in, both for school and home use.
- Remind participants that the last session will be project presentations and that additional school administrators will be invited to attend. Inform facilitator what group you will be a part of.
- Who will provide refreshments next session?

Part of next week's session involves having "stations" at which participants can examine select pieces of software. Each station will have a supervisor/demonstrator who is an inservice participant. Get four or five people to volunteer. Meet with them for a couple of minutes after the inservice session ends to explain what they will do and to give each their piece of software to work with.

4.1.4 Handouts

This section provides handouts needed by the participants during Session 1. The facilitator may find it useful to make some of these into overhead projector foils for use during the inservice. If you prepare your overheads using a computer such as the Macintosh, we recommend that you use 18 point type. (Fourteen point may suffice if you are in a small room and have a good quality overhead projector. Make some samples and try them out to see if they are easily and clearly visible.)

Note that part of the next section on materials must also be in the hands of participants during the session. Although the materials are designed primarily for use by secondary school students, we work through some of them during the inservice session to help illustrate the ideas being covered in this session.

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Session Descriptions

This handout contains a brief summary of the contents of each of the eight sessions of the inservice.

Session 1: Graphing to Represent Data

We will use *MECC Graph* on Apple computers and discuss line, bar and circle graphs of small sets of data. The issue of when and how to use a piece of software like this will be discussed. The general style or model for the remaining inservice sessions will be demonstrated and briefly discussed.

Session 2: Graphing Equations

Using *MECC Graph, MECC Graph Primer, Algebra Arcade, Green Globs and Super Plot*, we will discuss software that graphs equations and the uses of such software in the math curriculum. We will also look at a graphing program for the Macintosh called *Cricket Graph*. It provides an effective demonstration of the difference between relatively expensive software on a relatively expensive microcomputer versus relatively inexpensive and somewhat older software on a less expensive microcomputer.

Session 3: Spreadsheets

We will use *Formula Vision* and the spreadsheet on *AppleWorks*. *Formula Vision* is easy to learn and may be used in a wide variety of math classes. The spreadsheet in *AppleWorks* takes much longer to learn, and we will barely scratch the surface. Many teachers use spreadsheets to keep their gradebook records, and spreadsheets can be used to solve a wide range of math, science, and business problems.

Session 4: Problem Solving

Although problem solving is a theme that runs throughout the eight weeks of the inservice sessions, we also spend one session looking at software that is advertised as "problem-solving software." We will use *Mind Puzzles* by MECC, *Teasers by Tobbs, The Factory, Gertrude's Puzzles, High Wire Logic and Rocky's Boots*. The basic issue is whether and/or how the use of such software improves students' problem-solving skills.

Session 5: Databases

We will use the database in *AppleWorks* to illustrate the power of database software. We will learn to use Memo Pad, a simple database program made available to all teachers in the Eugene 4J school district. (*Editor's Note*: *FrEdBase* became available late in 1988, well after the inservice sessions described in this Notebook were conducted. *FrEdBase* is available from the California CUE organization or from ICCE. Once you obtain a copy, you are free to make additional copies for all of your students. It is an excellent piece of software to use in this type of inservice session.)

Session 6: Geometry and Visualization

We will use various pieces of software, including the *Geometric Supposers* series as well as *Geometry* for the Macintosh. We will examine *The Factory* and *Super Factory* for their possible value in improving a student's spacial visualization skills. (Research by a computer-in-education doctoral student at the University of Oregon provided evidence that use of *The Factory* contributes to improved scores on spacial visualization tests.)

Session 7: Inverted Curriculum

The current mathematics curriculum emphasizes students' development of good computational and symbol manipulation skills. But these are things that computers do well. The idea of an inverted curriculum supports spending more time on higher order skills (problem solving) and less time on lower order skills (computation and symbol manipulation). Students are provided with calculators and computers to aid in calculation and symbol manipulation.

Equation solving provides an excellent example. One can now purchase handheld calculators that have a SOLVE button. After the user keys in an equation (some can handle linear systems of equations) the equation can be solved by the calculator. During this session we will look at some of the software systems that aid in this part of problem solving, and we will discuss the long-range implications of making such software an everyday part of the math curriculum.

Session 8: Projects

The final session will be devoted to project presentations. Participants may work individually or in small groups. A natural grouping might be all participants from one school or all participants teaching a similar course. We will invite the district computer coordinator and several school administrators to attend this session.

MECC Graph: Lucy Van Pelt

This is a Performance Aid. It is a detailed set of directions for accomplishing a specific task with a particular piece of software.

1. Insert the *MECC Graph* disk in the drive. Close the drive door.

2. If the computer is off, turn it on. If the computer is already on, hold down the **Open-Apple** and **Control** keys, and press the **Reset** key (this is called a *warm start*). When you release these keys, the disk drive should start and the program will load. (If it doesn't work, repeat this step.)

3. When the disk drive goes off, press the **Space Bar** and read the description of the program on the screen. Then press the **Space Bar** again, and read the menu (a set of options) on the screen..

4. Choose item 1 (**Graph Name/Number Data**) by pressing **1**; then press the **Return** key.

5. The screen now displays samples of bar, line, and pie graphs, and a menu that allows you to specify what type of graph you want to have the computer do for you. Select Pie Graph by pushing the **3** key and then the **Return** key.

6. The LEGEND screen now asks you if "Do you want to use data stored on the diskette?" Type **Y** (for yes) and then the **Return** key.

7. The next screen begins with the directions "Select a data name." There will be one or more files named, and one of them will be LUCY VAN PELT. If it is already highlighted (black on white instead of white on black) then press the **Right Arrow** key and then the **Return** key. If it is not already highlighted, press the **D** (for down) or the **U** (for up) key an appropriate number of times to highlight the LUCY VAN PELT file name. Then press the **Right Arrow** and then the **Return** keys.

8. Now the screen display will show some data about A DAY IN THE LIFE OF LUCY VAN PELT. Answer **N** (for no) and press the **Return** key in response to the question "Do you want help entering labels for your graph?"

9. Notice the menu at the bottom of the screen. Select the graph option by pushing the **G** key.

10. Notice that the computer now draws a pie graph of the LUCY VAN PELT data. The graph shows the percent of the data that is spent in each of several different activities. At the bottom of the display is a menu.

11. Now feel free to experiment. For example, you might want to start over at step 2 of these instructions, but try different options. You might want to see what the LUCY VAN PELT data looks like when presented in the form of a bar or line graph.

(Alternate) MECC Graph: Lucy Van Pelt

Note 1: This is an alternative format for the MECC Graph Pie Graph Training Instruction Performance Aid. It has been designed to better fit the needs of younger students. Notice that the reading level has been lowered and the key strokes to be performed have been more clearly identified. This PA contains more detail than the PA designed for teachers. This PA would be even better if it contained pictures showing what the screen is supposed to look like after each major step.

Note 2: Writing really good Performance Aids is quite difficult. Usually it involves a trial and error process. One write the best PA they can, and then tries it out with the intended audience. Some members of the intended audience will not be able to follow the instructions. This will most likely suggest that some revisions are necessary. This cycle of writing, testing, and rewriting may need to be repeated a number of times before a satisfactory PA is produced.

1. Take the *MECC Graph* disk out of the disk jacket.
2. Keep your thumb on the label.
   Insert the *MECC Graph* disk in the disk drive with the label up.
3. Close the disk drive door.
4. If the computer is off, turn it on.

   - Turn on the monitor. The switch is usually on the front or the top.
   - Turn on the computer. The switch is on *your* left on the back of the computer.

   If the computer is already on,

   Hold down the Open-Apple and Control keys ***at the same time.***
   Continue to hold down these two keys.
   Press the Reset key.

   Release these keys. The disk drive should start .
   If nothing happens, repeat this step.
5. When the red light on the disk drive goes off, the program is loaded.
   You see a screen that identifies the program.
   You see the instruction "Press the Space Bar to continue"

   Press the Space Bar now.
6. Read the description of the program on the screen.
   You see an instruction to press the Space Bar again.

   Press the Space Bar now.
7. You see a *menu* on the screen. (A *menu* is a set of choices.)
8. You are to begin with choice number 1, Graph Name/Number Data

   Press the number 1.
   Press the Return key.
9. Your screen shows samples of bar, line, and pie graphs.
   There is a menu at the bottom of the screen
   You are to start with choice number 3, Pie Graph.

Press the number 3.
Press the Return key.

10. Your screen now contains four columns of horizontal lines.
The word LEGEND appears at the top on the left.
At the bottom, you see "Do you want to use data stored on the diskette?"

    Press the Y key.
    Press the Return key.

11. You see a screen that begins with "Select a data name."
You see a list of one or more files.
One of the files is called LUCY VAN PELT.
(If LUCY VAN PELT is not on your list, ask for help.)

12. You can use the U (for Up) and D (for Down keys) to highlight the names in the list.

    Press U and D several times.

    Notice that the names are highlighted as you move your cursor.

13. Now you are to choose LUCY VAN PELT.

    Highlight LUCY VAN PELT (use U and/or D)
    Press the Right Arrow key.

    This selects the LUCY VAN PELT file.

    Press the Return key.

    This gets the LUCY VAN PELT file.

14. The screen contains some data entitled A DAY IN THE LIFE OF LUCY VAN PELT.
You see the question "Do you want help entering labels for your graph?"

    Press the N key.
    Press the Return key.

15. You see a menu at the bottom of the page.
You are going to graph the data you see on the screen.

    Press the G key.

    The computer now draws a pie graph of the LUCY VAN PELT data.
    The graph shows the percent of the data that is spent in each of several different activities.

16. You see a menu.at the bottom of the screen.
Now you should experiment. Here are some ideas:

    - Start over at Step 9 of the above instructions, but try different options.
    - Find out what the LUCY VAN PELT data looks like when presented in the form of a bar or line graph.

Creating MECC Graph Diskette Files

[Note: This is an example of a Performance Aid. It is a detailed set of directions, rather like a recipe, for accomplishing a specific task with a particular piece of software.]

Getting started:

Load *MECC Graph.*
Select 1 from the **Main Menu.**
Make **selection** from the **Graph Menu**:
1. Bar   2. Line   3. Pie
Answer N to the question: Do you want help?
Answer Y and the program will aid you. For now, try N.

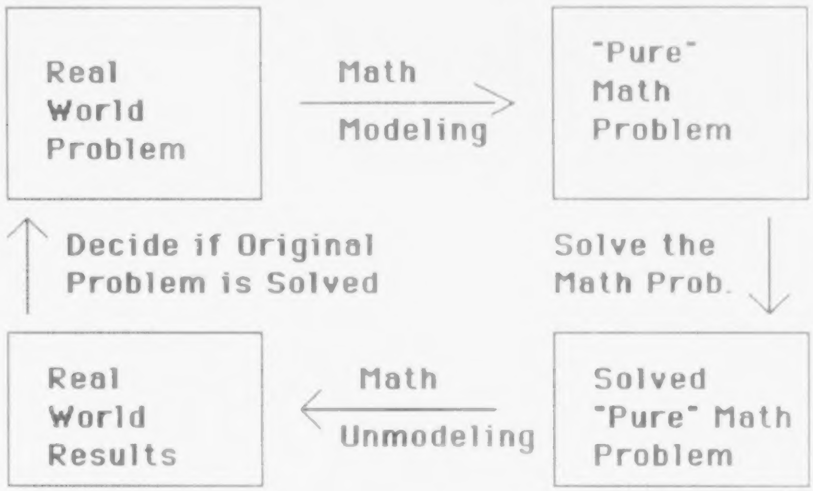
Creating your own file: (These instructions are for a line graph.)

Type your Graph Title: A Day in the Life of *your name*
Type your X-axis label: Activities
Type your Y-axis label: Hours
Type up to three names: *Your name*   *Partner's name*
Type in legends: Sleep
Eat
Play
Etc.

To type in data under the correct columns:
Press G to see if it looks appropriate.
If not, press C and make changes.
Press S for save and then **Y** for yes and give the data a **title.**

Game of the Week

The diagram given below suggests four major aspects or components of using mathematics to solve real world problems. One starts in the upper left corner with a real world problem that might be solvable through the use of mathematics. One then follows the arrows from box to box. Accomplishing the tasks suggested by the four arrows requires varying levels and types of student mathematical knowledge and skills. But math courses vary considerably in how much emphasis is placed on each of these four components. This issue becomes particularly important as it becomes clearer and clearer that computers can make a major contribution to "Solve the Math Problem." Indeed, once humans have figured out how to solve a particular category of math problem, there is a good chance that a computer program can be written to solve the problem. On the other hand, computers appear to be of much less use in performing the other three general tasks in solving real world math problems.



Game of the Week: Examine three different math courses you teach (or three different parts of one math course). For each, estimate the percentage of the course devoted to having students learn to "Solve the Math Problem" versus the percentage of time on the other three components. Write a brief report on what you find and your conclusions.

Generalizing the math problem-solving diagram: The ideas in the math problem-solving diagram can be generalized to most human problem-solving efforts. Each discipline has developed notation and vocabulary for describing/representing the problems of the discipline, and for representing methods to solve problems. Each discipline has an accumulated pool of knowledge of what problems are solvable, and how to solve them. Thus, if we select any discipline, we can substitute its name for the word "math" in the above diagram.

Still more generally, we can think of the memories stored in our brain as being patterns available for use in problem solving. We encounter a real world problem situation and we work to match it against a stored pattern. If we find an acceptable match, we than apply solution procedures that we have used previously. We then interpret the results in light of the original problem situation, and then check to see if the problem situation has been resolved.

For Extra Credit: Think about the previous two paragraphs. Write a short paper which is a critical analysis of these ideas.

Game of the Week Outcomes

[Note: This is not intended as a handout. Rather, it is a brief discussion to give the inservice facilitator some ideas on what outcomes may be expected from the Game of the Week.]

This first **Game of the Week** helps set a particular tone for the entire inservice. It is a task that all inservice participants can accomplish, and it gives insight into our mathematics education system. Typically, teachers will report that about 70% to 80% of the time in the math courses they teach is spent on the topic of "Solve the Math Problem." They indicate some desire to spend more time in the other areas, perhaps doing "problem solving." To the typical secondary school math teacher, problem solving in this case tends to mean dealing with word problems. How "real world" such word problems are is not clear.

Secondary school math teachers are aware of calculators. They understand the issue of learning to do pencil and paper computations versus learning to do calculations mentally or with a calculator. However, few secondary school math teachers have internalized the idea that the calculator analogy holds for much of what they teach. That is, much of what students are learning in secondary school mathematics courses is of a computational or symbol manipulation nature, and computers are quite good at such tasks.

The inservice facilitator should be aware that emphasis on lower order skills occurs throughout the curriculum not just in math. Benjamin Bloom is known for developing Bloom's Taxonomy, which gives a scale of lower-order to higher-order cognitive skills. The latter group, includes analysis, synthesis, and evaluation, and are sometimes called problem solving. Bloom estimates that perhaps 95% of the questions on teacher-constructed tests focus on lower-order skills. That is, even though educational leaders stress the importance of higher-order skills, it is the lower-order skills that dominate in the curricula developed and taught by most teachers.

Participant Log Sheet

One purpose of the inservice is to increase participant awareness of their use of computers and to encourage their increased and effective use. The **Participant Log Sheet** helps do this. Have participants fill out a log sheet each week. Encourage them to make entries at the end of each day rather than in the few minutes just before an inservice session begins. Collect the logs each session. Read them and make use of their content in planning and conducting the next inservice session. A sample Log Sheet is given below. You may want to modify it to fit your specific needs.

Name ______________________________ Date __________

Participant Log Sheet

Please use this form to record *all* of your computer-related activities, both at school and at home. Please set aside a couple of minutes at the end of each day to write in your entries. Be honest. It is quite appropriate to write NONE for days (indeed, for a whole week) if no use was made of computers.

Monday

Tuesday

Wednesday

Thursday

Friday

Weekend

Notes and Additional Comments:

4.1.5 Student Materials

These sample lesson plans are designed for use with students at a variety of grade levels. They exemplify the types of activities that can be done with students after inservice participants have learned the material in Session 1. There are many ways to organize and present a lesson plan. The examples given here can be adapted to a variety of instructional settings.

One type of homework assignment that may be given in an inservice of the type described in this Notebook is to have participants develop lesson plans. These lesson plans may be shared among participants as well as with their colleagues. It is helpful if all participants follow a common format (such as illustrated in these materials) when developing lesson plans to be shared.

Inservice facilitators will want to use some of these materials during the inservice session. If the session is more than two hours in length, it is appropriate to have participants work through a number of these student activities.

Index to Materials

Index to Materials	Page
(LP) Day in the Life of Lucy Van Pelt	2
(LP) Our Day Pie Graph	3
(LP) Interpreting Graphs	6
(LP) Pie Charting Lesson for *Our Oregon*	7
Graphing Ideas from the Real World	8

Day in the Life of Lucy Van Pelt

Description:

Pie Graph introduction
Grades 5-9
12 min. per pair of students

Materials:

1 *MECC Graph* diskette/computer
Apple computer w/lg monitor
(from 1-12 computers)

Students will use the pie graph to solve some percent problems. This can be an introduction for percents at the fifth grade level or review in general math. An alternative to using one computer per pair of students is to use a single computer with a large screen display for the whole class.

Before you start:

Set up equipment OR sign up for computer lab. Create a Lucy Van Pelt file that includes time spent complaining or crabbing, time spent watching TV, time spent operating her "5¢/consultation business," etc. Select ways of using time that will amuse your students, and select numbers of hours so that the percentages of the day spent on various activities will be reasonably nice numbers.

Lesson:

1. Use the Lucy Van Pelt file on *MECC Graph*, with each pair of students running the program.
2. Have students determine the number of hours and the percentage of the day that Lucy spends on complaining/crabbing, on sleeping, on watching TV, etc.
3. How many hours a day does she operate her 5¢/consultation business? Does this meet the standard of 25% of the average working day to qualify her for small business support?
4. Suppose that Lucy adds four hours a day to her TV watching time, and subtracts an hour off of each of four other activities. How much does this increase the percentage of the day spent on watching TV, and how much does it decrease the percentage of the day spent on the other activities?
5. Have students estimate their own time breakdown in percentages and present it as a pie graph. Does it make a difference if they choose a Monday or a Saturday? Decide which day of the week will be analyzed and assign the activity.

Follow-up:

- Students look through newspapers, magazines, and books to find pie graphs.
- Students predict a pie graph for another day in the week and then check it on the computer.
- Students create a pie graph for a pet.
- Students create a pie graph for one adult in their world.

Comments:

A day is divided into 24 hours. It is quite convenient to talk about certain fractions of a day, such as 1/2 day or 1/4 day. And, as you know, these lead to "nice" percentages. But people often talk about an hour or two hours. These are not nearly such nice percentages of a day. Have your students think about when is it most convenient and appropriate to talk about percentages as contrasted with just giving the actual quantities (25% of a day versus 6 hours)?

Our Day Pie Graph

Description:

Topic: Pie Graph introduction
Grade level: 3-5 (or older remedial)
Time: 12 min. per pair of students

Materials:

Software: *MECC Graph*
Equipment: Apple computer w/lg monitor
(from 1-12 computers)

Students will display the time allocation in their day in a pie graph. They will then compare pie graphs. This can be an introduction for percents at the fifth grade level.

Before you start:

1. Set up equipment OR sign up for computer lab.
2. Copy worksheets (on next two page). One worksheet is for writing down initial data (students can do two different days if they like), and the other is for drawing a picture of the circle graph produced by the computer. (This assumes that printers are not readily available.) For more advanced students, instead one can have students first sketch what they expect the circle graph will look like, using this second worksheet, and then do the graph on the computer.

Lesson:

Have one person in the room volunteer to go through the steps of setting up a pie graph on how they spend the hours in a day.

1. Do the hours add up to 24?
2. Does it make a difference if they choose a Monday or a Saturday?
3. Decide which day of the week will be analyzed and assign the activity.
4. Before the students use the computer:
    - They are assigned partners.
    - They fill in the worksheet on how they spend their time.
    - The total is 24 hours.
5. The students use the computer and enter the data for each.
6. The students record their pie graph on the worksheet.
7. The students color in the different ways they spend their days.

Follow-up:

- Students look through newspapers, magazines, etc., to find pie graphs.
- Students predict a pie graph for another day in their week and then check it on the computer.
- Students create a pie graph for a pet.
- Students create a pie graph for one adult in their world.

Our Day Pie Graph

_______________'s Graph
Name

In one day, how many hours do you:

sleep ______
eat ______
play ______
watch TV ______
go to school ______
__________ ______
__________ ______
__________ ______

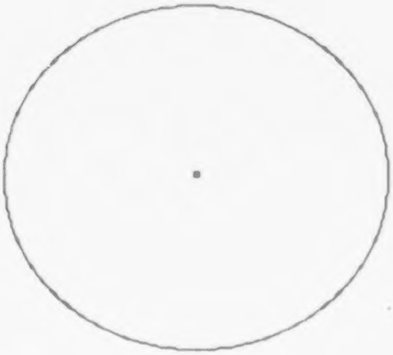
Total ______

_______________'s Graph
Name

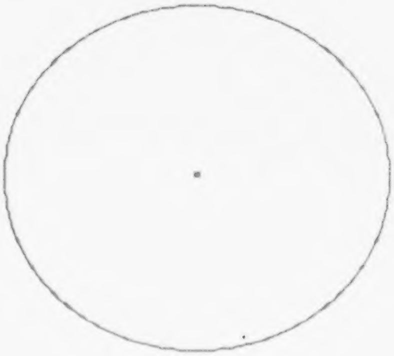
In one day, how many hours do you:

sleep ______
eat ______
play ______
watch TV ______
go to school ______
__________ ______
__________ ______
__________ ______

Total ______



________________ 's Graph
Name



____________________ 's Graph
Name

Questions:

1. Did you want to draw the pie graph by yourself or would you rather have the computer draw it?

2. Do you think using the computer will help you learn what a pie graph means?

Interpreting Graphs

Description:

Topic: Interpreting Graphs
Representations
Grade Level: 7-10
Time: 12-15 min.
Grouping: Whole Group Demonstration
OR 3 students/group
Objectives:

1. Interpret results
2. Identifying real-world situations

Materials:

Software: Interpreting Graphs
by Conduit or Sunburst
Equipment: Apple II w/monitor
Other materials: Graph paper for notes (optional)

Before you start:

1. Run the program to get a feel for the kind of graphs being posed.
2. Collect real-world graphs from public sources and textbooks.

Lesson: (Sequence of instructional activities)

1. Students select 1. *Relating Graphs to Events* from the Main Index.
2. Have students keep track of the different graphic representations as they learn them.
3. Have students graph the ups and downs of riding in a car or bus from home to school.
4. What does the graph of their weekly allowance look like?

Follow-up:

- Students gather graphs from outside sources and write a few lines explaining what the shape of the curve means.
- Writing Activity-Give a graph to the whole class (with or without the units on the vertical, horizontal, or both axes) and have each student write a story around the events represented in the graph.
- Have students close their eyes and graph different slopes in the air as you tell a story, or a diagram as you travel in an imaginary or real land.

Comments:

A major goal is to get students to visualize what a graph will look like before they actually have the computer draw the graph. Tracing graphs in the air and on computer screens helps students to remember some of the graphing concepts being illustrated.

Pie Charting Lesson for *Our Oregon*

Description:

Topic: Creating pie charts with software.
Grade level: 4-10
Time: Flexible--30 to 50 min.

Materials:

Software: *MECC Graph.*
Equipment: One Apple // per two students.

Grouping: Students work in pairs. On occasion, two pairs of students will need to be able to view one another's computer screens.

Objectives:

1. Students will create pie charts from data in the *Our Oregon* textbook, then modify the data and report the effects on the charts. (Editor's Note: *Our Oregon* is a typical elementary school social studies textbook. This particular lesson plan was first developed for use with students in the upper elementary school grades.)
2. Students will create new data sets and use them to create new pie charts.

Before you start:

1. Obtain sufficient copies of *MECC Graph.*

2. Prepare sample data files based on content similar to that of *Reading a Pie Graph* (p. 56) and *Skills Practice* (pp. 80-81) in *Our Oregon.* (Note: the MECC Graph disk prepared for CI^3 training has a data set that is related to the content of page 56.)

Lesson:

1. Have students load *MECC Graph* and the sample data file for page 56. Guide students through menu choices to create a pie graph of the data. Review questions 1-4 on p. 56.

2. Have students create a data table for the 1993 crop year. Instruct them to make changes in the balance of farm product values that reflect current trends; for example, the fact that Americans are eating less red meat and more poultry and vegetables.

3. Use the students' projected charts to discuss the following issues:
   a. If the price of a particular kind of food drops, what actions might farmers take?
   b. Can some crops simply be substituted for others? If farmers decide to grow different crops, what must they do to change crops? How far ahead must they plan?
   c. Suppose that exactly the same *amount* of each crop was grown in 1993 as was grown in 1983. Might the charts look the same or different? Why?

Follow-up:

With a different data set, a similar lesson can be done for *Skills Practice* on pp. 80-81.

Graphing Ideas from the Real World

This section contains a number of ideas and sources for graphing real world data using computer graphics. Encourage your students to look for additional sources of data graph; ask them to bring examples to class.

Math

Estimations (as early as preschool) then graph;
Making predictions based on initial information gathered;
Statistical surveys from any subject area;
Metric (or English) measurements of the body, small objects, large areas;
Equations, functions, relations; and
Time needed to accomplish various tasks.

Science

Sizes of the planets, density, distance from Earth, atmospheric composition;
Temperature, humidity, rainfall over time, overcast-amount of sun-visibility;
Growth of plant or animal under different experimental conditions;
Distance, velocity, acceleration;
Falling objects, gravity, wind resistance; and
Animal populations, growth and decline rates.

Health

Vitamins, minerals, or other composition comparisons;
Calories versus weight for various foods;
Fast food nutritional information, saturated versus unsaturated fats; and
Heart rate over time, varying according to activity.

Social Studies

Size comparisons for cities, or states, or countries' or their growth rates;
Size composition (farm land, mountains, lakes, etc.);
Population composition (cities, rural areas, small towns, etc.) or (percent literate versus decade) or ethnic backgrounds;
Economic growth (crops or mining or shipping or roads), (industrial, farming, services);
Buying power or cost of living comparisons versus different areas or different times; and
Projected growth rates.

Language Arts

Tell a story (on MECC Graph Primer);
Number frequency in ciphering codes; and
Number of books read by different classes.

Physical Education

Scores versus time on specific field and track events.
Number of push-ups one can do on a sequence of days.

4.1.6 Readings

The Readings sections of this Notebook are designed to supplement the materials presented during the inservice sessions. It is appropriate to assign these readings as homework for reading by inservice participants.

For the first session, it would be appropriate to make copies of 2.1 *Overview of Computers in Education* and 2.2 *Roles of Computers in Problem Solving*, and give them out to participants.

One goal in an inservice such as this is to encourage participants to read the literature. All math teachers should be aware of the publications of the NCTM. Nearly every issue of the *Arithmetic Teacher* and of the *Mathematics Teacher* contains computer-oriented articles, book reviews, and software reviews that are suitable reading material for this inservice. *The Computing Teacher* carries a regular column on roles of computers in math education.

4.2
SESSION 2: GRAPHING EQUATIONS

4.2.1 Narrative Overview

This session is a natural continuation of the first session (Graphing to Represent Data) and also an introduction to graphing of equations. Although *MECC Graph* is a relatively easy to learn and use piece of software, few math teachers master it in one session. Thus, we begin the second session with more practice in using this piece of software. Our goal is for participants to experience success and begin to build confidence in using a computer to help solve math problems. Certain features of *MECC Graph* that were not introduced last session, such as how to print out a graph, are introduced in this session.

In this type of inservice, an appropriate balance must be achieved between mastery in a few pieces of software and exposure to a large number of pieces of software. It is tempting to introduce participants to a very large number of pieces of software, giving them a shopping list from which to pick and chose what they will use. However, we recommend that you instead select a modest number of pieces of software and give participants a more in-depth opportunity to experience use of these pieces of software. (Vivian Johnson's Ph.D. dissertation work, which was a long term followup of this NSF project, suggests that most computer using teachers use only a very small number of pieces of software, perhaps two to four pieces, in their instructional work.) We have tried to help participants achieve a reasonable level of mastery for some software, while exposing them to a variety of other software. Participants are given opportunities to work further with software that fit their particular needs and interests.

Session 2 focuses on using a computer to graph functions. Many math problems can be better understood via a graphical representation. Moreover, graphics can be used to solve or help solve a wide range of problems. But the by-hand graphing of functions (even in two dimensions, and certainly in three dimensions) is a very time-consuming process. Many problems can be solved by graphical techniques. Using a computer, one can use guess and check, and trial and error, two approaches that take advantage of visual skills and the power of computers.

There is much more to integrating the computer as tool into the curriculum than just learning how to use specific software programs. In this session participants create a graph on *MECC Graph* and think about and discuss possible applications of the tool. If students are allowed to use the computers to draw graphs, will they understand the ideas involved in graphing any better? Can students extricate information from graphs or predict what a graph will look like if they don't spend time drawing them by hand? Does the visualization of a graph at the time of thinking about the problem help students to understand of the problem? Will students understand what causes a straight line to be graphed, as opposed to a curved line? Can they transfer pictorial information into mathematical generalizations?

One of the activities in this session is an off-computer activity in which participants are asked to create stories to fit some graphs. This is a new experience for many math teachers and for their students. It focuses on the link between graphing data and dealing with real-world problems. Some math teachers encourage their students to talk to each other about the math they are studying and to work together in problem-solving situations. Computers can be used as a focus of attention to increase the development of verbally-oriented mathematical skills. In one activity, participants generate data and then graph it. A team approach is used again, to model students working together to solve math problems.

The last half of this session allows participants to examine a variety of pieces of equation-graphing software using a workstation approach. Each workstation is staffed by a participant (volunteers from the last session) who have had the opportunity during the week to develop some skill in using their particular piece of software. There is time for participants to visit two or three workstations. If there are adequate copies of the software, a workstation may have several machines, allowing for simultaneous demonstration and hands-on activities.

The use of workstations in this inservice session can be duplicated in a secondary school classroom. That is, students can be given the task of mastering a piece of software and then being a facilitator at a workstation where other students learn to use the software. The idea of having students learn to help other students is powerful and useful.

Keep in mind these questions as this inservice session on graphics continues: Will these programs help students to understand an equation? Will using a particular piece of software allow more time to be spent on higher-order skills (problem solving) and less time spend on lower-order skills (computation and symbol manipulation)? Will students make use of the software if it is made available to them? Will transfer of knowledge occur from a graph to a mathematical sentence and vice-versa? Will students transfer their math class knowledge of using a graphics package to their other courses? Will graphing software help students to predict, since they will not actually draw the graph by hand? How much change in the curriculum would it take to integrate use of computer graphics as a routine tool? Can most teachers cope with this change? Can they use this in their curriculum without too much difficulty?

Graphing seems to be the one area of mathematics in which nearly all teachers seem to accept computers. Many teachers already use computers in this part of the curriculum. Use testimonials whenever possible to encourage those who still have not used computer graphics in their teaching to try it.

In doing this session, be aware that handheld, battery powered calculators with quite good graphics capabilities are available in the \$60-\$75 range (1988 dollars). The cost of a classroom set of such calculators may well be within the budget of a secondary school.

4.2.2 Script

Theme

Graphing activities for the classroom

Objectives

1. Interpreting graphs.
2. Using graph packages as a teacher tool.
3. Impact of visual versus numeric representation of information.
4. Impact of equation graphers and plotters on the curriculum.

Materials

Software
MECC Graph Primer
MECC Graph
MECC Graphing
Super Plot
Algebra Arcade
Green Globs
& Graphing Equations

Other
1 celery stick (≈5 in. long)
1 choc. chip cookie per part.
1 printer (if possible)

Handouts
Tell a Story (MECC Graphs)
(LP) Catch a Big Fish
Fishes Article from TCT
(HO) Fishing for Statistics
(HO) Creating MECC Graph Files
(HO) MECC Graph Prints Pics
(HO) Software Evaluation Form
(HO) Software Krib Sheets
(LP) Parallel and Perpendicular Lines
(LP) Simple Samples
(LP) Population Comparison
(LP) General LP for Simple Samples
(LP) Sizing Up Our World
MECC Graph Loading Instructions
Reprint of *Statistical Sampling of Fish Populations*

Refreshments

To be provided by participants from the school site where the inservice is being held. (*Editor's Note*: The math inservices rotated among the schools of the participants. The host school was responsible for the refreshments. This developed into a competition, with each school trying to out do the previous school in terms of quality of refreshments. This added a delightful new dimension to being in the inservice business.)

Introduction
5 Minutes
(3-4 Handouts)

Purpose: Experience graphing from a different perspective.

As participants arrive they receive a handout of a graph that has been printed off of *MECC Graph Primer*. Participants interpret the graph by telling a story. There should be three or four different graphs, so not all participants receive the same graph, but there is substantial duplication.

8 Minutes

Discuss the stories and compare those of participants who received the same graph. Are they the same? Why was this activity given? Where does it fit in with what is now being taught? Before learning to set up graphs? During? After? Is this idea in the present curriculum? Does it belong there?

Activity
25 Minutes
(MECC Graph
Fishes and Lakes)

Purpose: To experience the entire information cycle; that is, gathering, organizing, representing, analyzing, and editing. This activity is rich enough to be used across the K-12 curriculum.

Note: For details and a full explanation of the activity see the reprint of *The Computing Teacher* article, *Statistical Sampling of Fish Populations*, in the Handouts section. The article presents activities for various grade levels. Decide the level that best fits your participants. The activity as explained in the article is a good one for inservices.

Debrief
5 Minutes

Discuss the activity. What did participants learn? Discuss other mathematical activities, on or off the computer, that involve sampling.

Demonstration
3 Minutes
(MECC Graph
printouts)

Show examples of *MECC Graph* printouts. Discuss their uses with students, including the speed of obtaining graphs and their use as a quick way for teachers to produce graphs for overheads, worksheets, or tests.

Break
10 Minutes

Participants can print out their own graphs at this time.
Collect logs.

Debrief
10 Minutes

Debrief **Game of the Week**. Have participants share their ideas.

Activity
30 Minutes

Participants have three choices:

1. Explore the graphing programs: *Algebra Arcade, Super Plot, Graphing Equations (Green Globs)*, and *MECC Graphing* (graphing points, first quadrant graphing)
2. Work with *MECC Graph*. Develop and practice ideas for the classroom.
3. Work with *MECC Graph Primer*.

Closure

10-15 Minutes

The time allocated depends upon how long the previous activity is effective.
Here are some options:

1. Debrief the above exploratory activity. What uses can participants identify? In what other subjects besides math might these tools be useful?
2. Have participants form groups by school. Discuss ways of using and sharing what they have learned with others in their school.
3. Think of project ideas. Break into smaller groups or work individually. Teachers from different schools teaching the same subjects may want to discuss ideas or work together.
4. Set time and place of next meeting.

Game of
the Week

Now that you have seen the software available, where in your curriculum would it make the least difference? the most?
or
Ask your students: Now that computers are available, what do they think should change in terms of how math is taught and what they are expected to learn? Ask at least two different levels of math students.

4.2.3 Timeline

This sample timeline was built from the script given in the previous section. Each participant was given a copy of the MECC Graph software. In the first hands-on exercise, each group was responsible for loading the software to see that it booted correctly.

0:00-0:05	As participants arrive, give them the handouts and ask them to make up a story about the graph on the first page. They can write it on the bottom of the page.
0:05-0:13	Debrief. Let a few people tell their stories. Why is this activity being done? Is it an important concept?
0:13-0:40	Activity I. MECC Graph with Fishes/Lake. Participants should be in groups of 4. Have them read the article *Statistical Sampling of Fish Population* and do the activity. Each group should graph its findings using *MECC Graph* and leave it on the computer screen when finished. (Note: Make sure that each group has booted off the copies of *MECC Graph*.)
0:40-0:50	Debrief. What did they learn? Can they think of any other math activities that use sampling?
0:50-0:55	Demonstration. Show examples of *MECC Graph* printouts and show them how to do it. If there are enough printers, have each participant print out a graph. If participants wish, they may print out a graph during the break.
0:55-1:05	Break. Collect logs and load up the following software on different machines. (Each person running a workstation can load their own software.) • Leave one machine loaded with *MECC Graph* and attached to a printer • *MECC Graph Primer* • *MECC Graphing* • *Algebra Arcade* • *Super Plot* • *Graphing Equations (Green Globs)*
1:05-1:15	Get group together and debrief Game of the Week. After the discussion, introduce the "experts" for each workstation. Tell the participants they may visit two stations for 15 minutes each. Describe the pieces of software and the location of each. Have a short performance aid sheet available for each station.
1:15-1:45	Participants each spend time at two workstations.
1:45-2:00	Closure. Debrief the activity. Where might these different pieces of software be used. Are they helpful? Can they be easily integrated? Announce new Game of the Week. Remind participants of the location of the next meeting and to fill in their log sheets. Keep the room open for 30 more minutes for anyone who wants to look at more software.

4.2.4 Handouts

This section contains handouts needed in Session 2. The facilitator may find it useful to make some of these into overhead projector foils for use during the inservice.

Note that some parts of the materials must also be in the hands of participants during the inservice. Although the materials are designed primarily for secondary students, we work through some of them to help illustrate the ideas covered in this session.

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Statistical Sampling of Fish Populations

by Judi Mathis

[Reproduced with permission from ICCE. This article first appeared in The Computing Teacher, *June 1986.]*

Students growing up in the information age need to understand sampling, statistics, predictions, and interpreting graphs. They see samples and opinion polls in newspapers and magazines and ought to know what they mean. A well-designed sample, accounting for proper representation of each stratification of the population, can poll less than one percent of a total population and predict fairly accurately the opinions or needs of the entire population through mathematical formulas developed to do this.

The following activity helps students develop a basis for understanding elementary statistics. The activity is outlined for third grade, and elaborations are given for grades 4 through 12. The emphasis in the activities, especially in the lower grades, is on experiencing the sampling procedure, gathering and organizing data, feeling comfortable with making estimations, and developing an intuitive sense of range of accuracy. Students need to experience situations where an exact answer is not necessary.

The computer is used to record gathered data, organize and report compilations of data, perform calculations, and present information graphically. The teachers doing this activity used *MECC Graph*. Other titles suitable at the elementary level include *Easy Graph* by Grolier, *Exploring Graphs and Tables* by Field Publications, and *MECC Graph Primer* by MECC. Any good software that transfers information from the data base to the graphing tool is desirable for middle school and above. Spreadsheets can offer help in organizing and recording data and in the subsequent calculations.

This activity and its elaborations were used in training workshops for the CI^4 (Computer Innovations Integrated Into Instruction). [Editor's Note: The project is now called CI^3, Computer-Integrated Instruction Inservice] research project at the University of Oregon and subsequently by several participants in their classrooms. For more information on the project, see "Effective Inservice for Use of Computers as Tools," by David Moursund in the February 1986 issue of *The Computing Teacher*.

Let's Go Fishing

Description

Topic: Statistical Sampling of Fish Populations
Grade Level: 3
Time: 10 minutes at desk + 20 minutes on computer
Grouping: Students in groups of 2, 3, or 4

Objectives

1. Learn sampling methods: gathering, recording and sorting data
2. Practice measurement (for activities at some grade levels)
3. Graph sampling results using the computer
4. Make predictions and "guesstimations" and determine range of acceptable error

Materials

Software: *MECC Graph*
Equipment: Apple II

Other materials: Fish patterns and colored paper, and brown paper bags. (Editor's Note: The original article contained a large number of pictures of fish that could be cut out and used to create the fish population. In this copy of the original article we have provided you with just one picture of a fish, plus two variations on it. The original fish was created in MacPaint. In MacWrite format, it can be stretched into a variety of shapes to produce a variety of fish. This is illustrated at the end of this article.)

Before You Start

Students should have prior experience using *MECC Graph*. Photocopy the fish patterns onto different colored paper, or color the fish a variety of colors. Cut into rectangles and group samples in brown paper bags with the name of a lake, or location of a lake, on each bag. For example, using three colors of fish, bag 1 contains three blue, three green, and six orange; and bag 2 contains six blue, three green, and three orange. Prepare one bag per group. (Keep the number and type of fish in each bag recorded in a safe place.)

Lesson (Sequence of Instructional Activities):

1. Each student catches a fish from the lake (the brown paper bag);
2. Records the color of the fish; and
3. Replaces it in the lake (the bag) and stirs up the lake.
4. After repeating the above steps a specified number of times, students graph their results.
5. Each group makes a guesstimate as to the total number of fish and number of each color.
6. Combine and present all of the group's results. Compare the small samples, the whole group sample, and the original sums in the fishbowl. Which was the best predictor, small or whole group?

Post Activities

1. Do a statistical sampling of a new lake. Have students predict the total in the lake and the number of each color. The group with the best estimate gets a reward.
2. Within the school, students can take statistical samples of eye color, categories of favorite books, kinds of pets, etc.
3. Within the community, students can take statistical samples of number of video machines or gum machines per building, number of trees in the park, etc.
4. Students can poll their parents on some condition when they were in third grade (e.g., distance from school, coldest or warmest temperature during a school day, etc.).
5. Vary the available fish ponds, have students do the lesson again, then post the contents of each bag without naming them. Students can match the "real" data with their predictions to guess which bag is theirs.
6. Have students bring articles from newspapers and magazines based on samples.

Comments

1. Sampling activities can be done in a piecemeal fashion as an ongoing project, rather than allocating a single block of regular class time.
2. Concrete materials are appropriate at all levels to deepen the understanding of the concepts.
3. Have students create their own survey to answer questions they pose.
4. Relate the sampling process students have experienced to real-world examples such as presidential polling, location of blue whales, gypsy moth populations, etc.

Examples for Other Grade Levels

Fourth grade: Using fish of varying length; for each sample, determine the maximum, minimum, and range.

Fifth grade: Measure, record, and determine the average length of the fish sampled. Take a second sample and determine the average. Do they agree?

Sixth grade: Record fish color of a sample and predict ratios of certain-colored fish to the total number of fish (using fractions). Empty the lake and count the fish and determine the exact fractions. How close were the predictions?

Seventh grade: Record samples from different locations on a lake and match up the sample with the location (e.g., stream runoff, near a boat dock, middle of the lake, close to the dam, etc.) Predict environmental impacts on populations.

Eighth grade: Gather fish information on local lakes or rivers by contacting your fish and game board or consulting your local newspaper or a textbook about your state. Each group makes a sample bag representing their lake. Other students sample the bags, predict the breakdown, and compare their results.

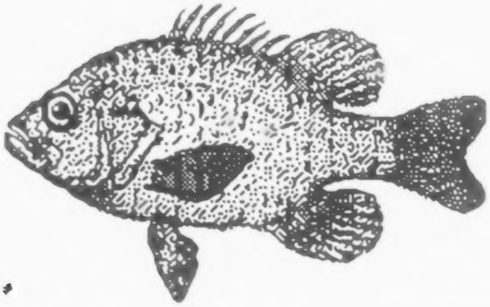
Ninth grade: Sample, record vital information and determine probabilities for each length of fish, type of fish, or color of fish.

Tenth grade: Determine the mean, median, mode, and standard deviation of a normal population.

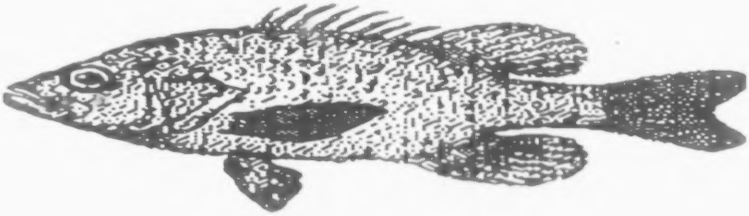
Eleventh grade: Sample, measure, and record on Day 1. Student or teacher then changes the sample by adding fish or replacing with longer fish. Sample, measure and record for Day 2, which represents one week's or one month's growth. Students continue for four or five samples and predict growth rates. Compare with actual populations. What kind of a curve is this?

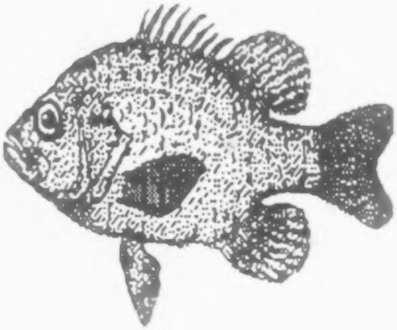
Twelfth grade: Catch a fish, measure, record, and repeat while keeping a running average. What percentage of a sample must be taken until the error (difference between sampling average and real average) is within a certain value? Now change the value: How does the sampling percentage change? (A spreadsheet would be most effective for this activity.)

[*Note*: The original article contained a number of pictures of fish that could be duplicated and then cut out and colored. One of the fish is pictured below. All of the fish came from one "original" such as this.]



Next we give two more pictures of the same fish. All we have done is to do some stretching and/or shrinking in the horizontal and vertical dimensions. Such is the "magic" of having a picture (created in MacPaint) in a MacWrite file.





Fishing for Statistics

Data Recording Form

Record your "fishy data" here:

Classes or Characteristics	Counts

MECC Graph Loading Instructions

[Note: This is a Performance Aid. It is a detailed set of directions for accomplishing a specific task with a particular piece of software.]

1. Insert the *MECC Graph* disk in the drive. Close the drive door.
2. If the computer is off, turn it on. If the computer is already on, press the **Control, Open-Apple** and **Reset** keys simultaneously (this is called a **warm start**). When you release them, the disk drive should start and the program will load.
3. When the disk drive goes off, press the **Space Bar** twice.
4. You should see a screen titled *MECC Graph*. Choose item 1 (**Graph Name/Number Data**) by pressing 1; then press the **Return Key.**
5. When the disk stops spinning, select item 1, 2 or 3 (depending on what kind of graph your group wants) from the main menu.
6. When you see the screen with the word **Legend** at the top, answer **"N"** to the question, "Do you want to use data stored on the diskette?"
7. Now the *Legend* table returns. Answer either **"Y"** or **"N"** to the question "Do you want help entering labels for your graph?"
8. Fill in the information your group found from the **Fishing for Statistics** activity.
9. Select the **graph** option by pressing **"G."**
10. Select the **menu** option by pressing **"Q."** From the main menu, you may select another graph to look at.
11. When you finish, select the **menu** option. From the graph menu select item 4 (**Return to main menu**). Answer **"Y"** or **"N"** to the question "Do you want to store this information for further use?"

MECC Graph Prints Pictures

[Note: This is an example of a Performance Aid. It is a detailed set of directions, rather like a recipe, for accomplishing a specific task with a particular piece of software.]

Setting up the Printer Support on *MECC Graph*:

The **bottom** of the **Main Menu** reads: "Print Option is OFF."
Select: 4. Printer Support from the Main Menu

1. Identify Printer Type -- only 3 combinations possible
    1. Apple DMP / Parallel Card
    2. Apple Imagewriter / Serial Card
    3. Printer / Grappler Card

    Answer **Y** if you have one of these selections and then the corresponding number
    Otherwise **N** results in a dead end.

2. Select Printer Slot Number.
    Only 2 choices possible: Slot 1 or 2
    Answer **Y** and then the slot number.

3. Test the printer.

4. Select Print Option -- toggle to **ON** by answering **Y** to the query.

5. Return to Main Menu.
    The last line of print should now read "Print Option is **ON**."

Printing Graphs and Legends while using the program:

Located in the lower right hand corner is P = print
  Press **P** to **print** the **legend.**
  Press **S** for small or **L** for large.
  Answer Y or **N** to identify your data.
  If **Y** then the questions are:
    Type your name.
    Type your class name.
    Type your project name.
    Type the date.

Press **G** to see the graphic display.
  Located in the lower right hand corner is P = print graph.
  Press **P** to **print** the **graph**.
  Press **S** for small or **L** for large.
  Answer **Y** or **N** to identify your data.
  If **Y** then the questions are the same as above.

MECC Graphing Primer
Pie Graph Training Instructions

[*Note: This is a Performance Aid. It is a detailed set of directions, for accomplishing a specific task with a particular piece of software.*]

1. Insert the *MECC Graphing Primer* disk in the drive. Close the drive door.

2. If the computer is off, turn it on. If the computer is already on, press the **Control, Open-Apple** and **Reset** keys at the same time. When you release them, the drive will start and the program will load.

3. When the drive goes off, press the **Space bar** twice.

4. You should see a screen titled *MECC Graphing Primer*. Choose item 3 (**Exploring Pie Graphs**) by pressing 3; then press the **Return** key.

5. Read the information on the screen and then press **Return**.

6. Select Item 2 (Quick Review) from the **Pie Graphs** menu. This is a sequence of "screen pages" that gives some information about pie graphs. Press the **Space bar** to "turn" each page. Unless you wish to read the screens again, enter **N** at the review prompt on the last page.

7. From the **Pie Graph** menu, select item 3 (**Pie Games**). There are two informational pages. Then you have your choice of games. Choose either. Enter data into the table when instructed to do so. Any data will do—you can just make it up. Answer "N" to the question "Would you like to print this graph?" Create another graph if you wish, or play the other game by choosing **Pie Games** again.

8. **Optional:** If you have time, select item 4 (**Tell the Story**) from the **Pie Graphs** menu. In this activity, you must make up a story to explain a graph. The story can only be as long as the space between the [**brackets**]. You don't have to press **Return** at the end of each line; the computer takes care of that.

9. When you finish, select item 5 (**Return to main menu**) from the **Pie Graphs** menu. From the *MECC Graphing Primer* menu, select item 5 (**End**). Please remove the *MECC Graphing Primer* disk from the drive and leave the computer on.

Games on MECC Graphing

[Note: The following four "Games" are available on the MECC Graphing disk.]

1. **Quotes**
   You type in a message that you want coded in terms of ordered pairs. The program makes up a first quadrant grid with letters naming the points. To figure out the quote, the student must find the correct letter via the ordered pair given.

2. **Graph**
   You are given an equation and four values for x. You must solve for y. The program will graph the equation based on your values of y. You have two chances to correct any errors. You have a choice between positive and positive/negative x values.

3. **Hurkle**
   In this game a figure called a hurkle "hides" on a grid point in a square grid. When you type in guesses for the coordinates of the hurkle, the program gives you hints that will help you to correct your guesses.

4. **Nomad**
   In this game you are at a certain point on a map-like grid and need to go to some other point on the map. You can move the figure by giving directions and speed.

Algebra Arcade Lab

[This is a Performance Aid for using *Algebra Arcade Lab*.]

1. Find someone to play *Algebra Arcade* with you. You will be lonely if you have to play it by yourself.

2. Load the program. Choose the **two player** game. Follow the instructions and **press any key**.

3. To begin play, press the **Space Bar**.

4. Ten little Algebroids should have appeared on the screen along with one shifty-eyed Ghost. The object of the game is to write an equation that goes through as many of the Algebroids as possible without hitting the Ghost.

5. The game always opens by accepting any type of equation. The syntax for the equations is fairly specific. It does not like 2x, but does like 2*x (* is Shift 8). It also needs exponents entered as x^2 (^ is Shift 6). Enter an equation and press return.

6. It is always possible to practice an equation before actually trying it. A box of four choices will be flashing in the lower right corner. If you **press P** while this box is flashing, you will be able to practice an equation. **Press P** and then **Return**. The next player now gets a practice turn. You may continue to take practice turns by pressing **Return**. When you are ready to go back to the game, **press P** (for play) while the box is flashing. The other items in the flashing box allow the user to: **G**-reset the game; **E**-erase lines on the practice field; **F**-change features of the game; or **A**-bring out a new set of Algebroids.

7. Continue playing until you are ready to explore some of the other features of the game. While the box in the lower right corner is flashing, type **F** and press **Return**. You should now see a list of features. One of the more interesting ones is option **4**. Choosing this gives you another list. You may choose the family of equations you wish the game to accept or create your own family of equations. Once you decide on the family of equations you will return to the Features menu. Here you will have to set item **3** to "on." Now the game will only accept the family of equations that you have specified.

8. Try different features. Play some more games. Have fun and avoid the shifty-eyed Ghost.

Back in the Classroom:

Where can this software be used in your curriculum? Will You use it for demonstration or student exploration?

SuperPlot Lab

[This is a Performance Aid for using *SuperPlot Lab*.]

1. **Load** *SuperPlot*.
2. Pressing the **Space Bar** moves the highlighted box through the list of choices.
3. Highlight "Enter a function" and press **Return.**
   Enter the equation: $y = 2x + 11$ and press **Return.**
4. "See the graph" should be highlighted. Press **Return.**
5. Where is the intersection of the line and the y-axis?
   Press H and change the limits of the graph. The options will continue to appear until you choose one. Make changes to the graph.
6. Limits can be changed from the main menu. If you are not at the main menu press **Esc**. Now highlight "Set new limits" and press **Return.** Enter new limits for the graph. Examine the new graph.
7. If you wish to change the graphing mode (sound, color, dots), highlight "Change graphing mode" and press **Return**.

Algebra Activities

Try entering equations that would be used in your classes.

Exponents are to be entered by pressing **Shift** and the **6** at the same time (^ appears). Once the exponent is entered, pressing **Return** leaves superscript mode and returns to the normal position.

How does the program accept fractions and decimals? As exponents?

Is is possible to graph $x = 3$? Can the format be changed from
$y = ????$ to $x = ????$

Trigonometry Activities

Enter some trigonometry functions. Do you need to type the whole name? Keep track of which keys represent which functions.

Are there responses to certain functions that are not appropriate such as $y = \ln 0$?

Back in the classroom:

Where can this software be used in your math curriculum? Will you use it for demonstration or student exploration?

Green Globs
(Graphing Equations Lab by Conduit)

[This is a Performance Aid for *Green Globs*.]

1. Load the *Graphing Equations* disk into the computer.
2. Select 0 to learn that **>** is the prompt and the computer is waiting for input, the **back arrow** is used to **erase** characters, **Return** to continue, **Esc** to back up, and **Esc Esc Esc** to return to the main menu.
3. Select **2. Green Globs** and press **Return.**
4. Press the **Space bar** to see the rules. Read them if you're a novice to the game. Use the ^ for exponents (which are restricted to 1 digit. The ^ is located at shift 6). Y = an expression in X **OR** X = an expression in Y.
5. **Select 1** for the Novice Game.
6. To warm up, type in linear equations of the form: Y = mX + b or aY + bX = c.
7. After playing a game or two, expand your horizons - try equations of the form: $r^2 = (X - a)^2 + (Y - b)^2$ where r is the radius and (a,b) is the center.
8. Okay, expert, go for it! Challenge everyone in the room to ellipses at 7 equations.
9. **Esc** to the Main menu and look at the other programs on the disk. Explore the record keeping feature.

Back in the classroom:

Where does this activity fit in the math curriculum you teach?

How can this be used for whole class demonstration? Individual students? Groups of students?

What materials might aid the students as they use this program?

Game of the Week

Do one of the following two games.

1. Now that you have seen some of the math graphics software that is available, discuss where in the math curriculum you teach would such software make the most difference? Give some specific examples and general reasons why you feel this is the case. Where in the math curriculum you teach would graphics software make the least difference? Give some specific examples and general reasons why you feel this is the case.

2. Ask your students: Now that computers are available, what do they think should change in terms of how math is taught and what they are expected to learn? Ask at least two different levels of math students. You might have them provide written responses, or you might carry on a whole class discussion. The main goal is for you to gain increased understanding of what your students think and feel about these questions. Write a report on what you find out.

Results of Game of the Week

[Note: This is not intended to be a handout. Rather, it gives the inservice facilitator an indication of the types of responses that participants might provide in responding to the Game of the Week.]

There were two choices for this week's game. The results for both follow:

1. Now that you have seen some of the math graphics software that is available, discuss where in the math curriculum you teach would such software make the most difference? Give some specific examples and general reasons why you feel this is the case. Where in the math curriculum you teach would graphics software make the least difference? Give some specific examples and general reasons why you feel this is the case.

Least	**Most**
initial instruction	problem solving
record-keeping	drill and practice
general practice	low level skills
AP calculus	graphing
classes above algebra	classes below algebra

The above answers were the ones that occurred the most often from inservice participants who responded to this question.

2. Ask your students: Now that computers are available, what do they think should change in terms of how math is taught and what they are expected to learn? Ask at least two different levels of math students. You might have them provide written responses, or you might carry on a whole class discussion. The main goal is for you to gain increased understanding of what your students think and feel about these questions. Write a report on what you find out.2.

Main answer from 6th graders (average to below average): Nothing, we still need to learn how to do the math because:

- You need to make sure the computer does it right.
- What if no computers were available?
- Can't do certain things on a computer (ie, measure things).
- Knowledge is good.
- What if the computer malfunctions?
- I don't want to be stupid.
- Need knowledge for tests.
- Need to know what math symbols mean in the real world.

7th graders (average to above average): We still need to learn math because:

- Computers don't think.
- Need the knowledge in case no computers are available.
- Mental math is good for you.

Use a computer to:

- Learn how to use a computer and how it works.
- Make it easier, because a computer can do "hard" problems.
- Less talking and more fun.
- Take a teacher's place!

8th grade algebra students: We still need to learn math because:

- You need to check computers.
- Computers can't do everything.
- What if computers aren't available?

High school students responded similarly:

Pros

- Computers in math would increase knowledge in all fields.
- Use computers to solve equations and proofs since not used in real life.
- Can use time to learn real-life things, but then if computers disappear, we're in trouble.
- Use computers to replace teachers so each student can work at his or her own pace.
- Don't need to use a whole sheet of paper to solve a problem.
- No textbooks, grading more efficient, immediate feedback.
- Fun, but may be harder to understand.
- Let computers do the work and we do the applications.
- Much more fun—a desire to use software.
- 3-D for geometry helpful—visualization easier.
- Can review as necessary.
- Trial and error—time to do many.
- Can go faster with more difficult problems to tackle.
- Individualization, independence.

Cons

- Concepts behind math won't be understood - answers just appear.
- Question reliability.
- Need to know formulas to use a computer or calculator.
- No knowledge needed except programming—not using our brains.
- What happens if there are no computers available?
- Imagination will decrease.
- Impersonal - a teacher knows when you don't know it!
- Harder to type than write.

In general, the lower level students in high school felt we should leave well enough alone and leave computers out of the classroom. They seemed to feel confusion and were wary of computers. The higher level kids seemed willing to try computers in the classroom. Many provided responses such as "It sounds like fun" or "It'll make the class more interesting."

4.2.5 Materials

These sample lesson plans are designed to be used with students at a variety of grade levels. They represent the types of activities that can be done with students after learning the material in Session 2.

Inservice facilitators will want to use some of these materials during the session. If the session is more than two hours in length, it is appropriate to have participants work through a number of these student activities.

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(LP) Comparing the Populations of Oregon with Other States 6
(LP) General Lesson Plan for Simple Samples 7
(LP) Sizing Up Our World 8

Catch a Big Fish

Description:

Topic: Statistical Sampling of Fish Population
Grade Level: 4-9
Time: One period
Grouping: Students in Groups of 2, 3 or 4
Objectives:

1. Teach sampling methods
2. Measurement practice (cm or inches)
3. Graphing sampling results

Materials:

Software: *MECC Graph*
Equipment: Apple //computer
Other materials: Cardboard fish

Before you start:

Use the pictures in the *Statistical Sampling of Fish Population* article to create a fish pond of paper or cardboard fish. Color them various colors.

1. Determine variables to be analyzed: How many different kinds, how many fish, size, color? This determines the grade level and the difficulty.
2. Students should have experience using *MECC Graph*.
3. Place all the "fish" in a "fish bowl" (a paper bag will suffice).

Lesson: (Sequence of instructional activities)

1. Students catch a fish in the fish bowl one at a time.
2. Record the length, type, and color of the fish.
3. Replace it in the bowl.
4. After recording a specified number of data points, the students graph their results by use of computer graphics.
5. All of the groups of results are combined and presented. Compare the small samples, the whole group sample, and the original sums in the fish bowl. Which was the best predictor—small or whole group?
6. Do a statistical sampling of a new fish bowl.
7. Have students predict the total in the fish bowl. Reward the best-estimating group.

Follow-up: Students can

1. Take a statistical sample within the school.
2. Take a statistical sample of local businesses.
3. Poll their parents on some items of data.

Comments:

1. Vary the available fish ponds and post the final results. Have students match the "real" data with the fish pond.
2. Explain that this is how scientists make predictions in the real world, whether fish ponds or presidential races.
3. Have students bring articles from newspapers and magazines based on samples.
4. This can be done in a piecemeal fashion, or as an ongoing project, rather than allocating regular class time.

Parallel and Perpendicular Lines

Description:

Topic: Graphic representations of parallel and perpendicular lines.
Grade level: 8-12.
Time: 12-15 minutes.
Grouping: Whole class demonstration
Objective: Students will explore the similarities and differences in the equations for parallel and perpendicular lines.

Materials:

Any equation graphing program & and appropriate computer w/lg monitor or projection display system.

Before you start:

Set up equipment.
Lines and linear equations have already been introduced to your students.

Lesson:

1. Give the students two equations such as: $y = 2x + 5$ and $y = 2x - 4$.
2. Have students predict what the lines look like.
3. Graph the two lines using the graphing program.
4. Students supply another line parallel to those two.
5. Students generate a different pair of parallel lines.
6. Include at least one set of parallel lines with negative slope.
7. Display an equation like $y = 3/5\ x - 1$ and have students predict the equation of a line perpendicular to it. Guess and check.
8. Find two lines perpendicular to it.
9. Begin with a line with negative slope like $y = -1/2\ x + 1$ and have students predict a line perpendicular to it.
10. What about $y = 3x - 8$ or $y = -4x + 1/7$?

Follow-up:

- Where do parallel lines (or line segments) occur in the real world? (Look for pictures, and perhaps prepare a bulletin board display.)
- Where do perpendicular lines (or line segments) occur in the real world?
- Have students sketch equations and predict parallel and perpendicular equations to given linear functions.

Comments:

Students can improve their estimation and intuitive guessing by using lines that have other than integer slopes. Indeed, giving students only examples and exercises having inter slopes may lead them to believe that only integers are allowed.

Graphing Problems
(Activities to be done using SuperPlot)

I. Predict and Graph. Give students a (computer-generated) handout with some sets of coordinate axes for graphing equations, and some equations to be graphed. Students are to rapidly sketch the equations, and then check their results by use of a computer graphics package. A sample is given on the next page.

II. Parallel and Perpendicular Lines

Which of these is/are parallel to $y=(2/5)x+1$?

a) $y= 2x+5$
b) $5y=2x-10$
c) $y=.4x+3$

Find the equations of two lines that are perpendicular to $y=(2/5)x+1$?
(Check by graphing)

III. Find the roots of
$x^4 - 23x^2 + 18x +40$
(Use zooming features)

Create two functions with roots -2 and 2. (Check by graphing)

IV. Predict how these three graphs differ:

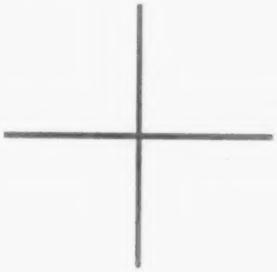
$y=\sin(x/4)$
$y=\sin (x+ \pi/4)$
$y=\sin x + \pi/4$

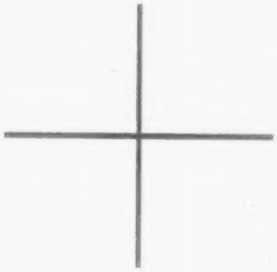
Predict what the sum of $y = 2 \sin x$ and $y = \cos x$ looks like.
(Graph each separately and then $y = 2 \sin x + \cos x$)

Predict and Graph

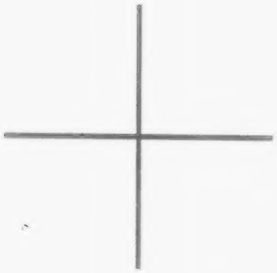
1. y = 3x

2. y = ln x





3. y = sin(3x)



Comparing the Population of Oregon with Other States

Description:

Topic: Bar graphs comparing population
with other states
Grade level: 5-10
Time: 12-15 min. for whole class demonstration
OR pairs/ computer
Objectives:
- Students will gather information on another state and compare it with Oregon's.
- Aids the ordering and perspective of information regarding their home state.

Materials:

MECC Graph (one/computer)
Apple computers (1-12)

Discussion: A bar graph can be effectively used to display a set of data (such as population of several states) for easy visual comparison. Another good example of the type of data that one might want to display with a bar graph is the population of a state every ten years for the past fifty years.

Before you start:

Set up equipment.
Gather information on Oregon and other states or use data from this example:

	Area (Sq miles)	**1982 Population**
Oregon	96,981	2,649,000
Washington	68,192	4,245,000
North Carolina	52,586	6,019,000
South Carolina	31,055	3,203,000

Lesson:

- Present the sample above to the whole class.
- Have students find the population statistics for other states.
- In pairs, students compare population sizes or growth between Oregon and other states using bar graphs.
- Have students present their findings to the rest of the class.

Follow-up:

Students can also compare urban versus rural distribution, minority populations, industries, etc. This could also be done as a comparison between the U.S.A. and other countries.

General Lesson Plan for Simple Samples

Description:

Topic: Statistical sampling with replacement
Grade Level: 5-12
Time: 15 min off +15 min on computer
Grouping: Students in groups of 2, 3, or 4
Objectives:

1. Introduce sampling methods,
2. Organize data to be collected,
3. Data gathered and recorded,
4. Graphing sampling results, and
5. Statistics: Mean, median, mode &/or standard deviation

Materials:

Software: Any graph software
Equipment: One or more computers
Other materials: Sampling sets of materials

Before you start:

1. Create or select a collection to be sampled. Suggestions include: colored beans, painted macaroni, construction paper pictures, colors or makes of automobiles observed at particular sites or times, etc.
2. Determine variables to be analyzed. How many different kinds, how many of each, size, color? (This determines the grade level difficulty.) Students should have experience using the graphing tool selected.
3. Place all the objects in paper bags or other storage devices. (Teacher keeps the secret totals in secure place.)
4. Have students bring articles from newspapers and magazines based on samples as an introduction to this topic.

Lesson: (Sequence of instructional activities)

1. Students select an object one at a time.
2. Record the appropriate information for each object.
3. Replace object.
4. After recording a specified (small) number of data points, the students graph their results.
5. All of the groups of results are totaled together and presented. Compare the small samples, the whole group sample, and the original quantities. Which was the best predictor - small or whole group?
6. Do a statistical sampling of a new collection of similar objects.
7. Have students predict the total in the collection. The group with the best estimate gets the reward.

Follow-up: Students can

1. Take a statistical sample within the school.
2. Take a statistical sample of the local businesses.
3. Poll their parents on some items of data.
4. Bring articles from newspapers and magazines based on samples.

Comments:

1. Vary the available collections and post the final results. Have students match the "real" data with each collection.
2. Explain that this is how scientists make predictions in the real world (e.g., presidential races).

Sizing Up Our World

Description:

Topic: Metric measurements
Grade Level: 3-8
Time: 15 min off +10 min on machine
Grouping: Students in pairs
Objectives:

1. Students will gather data,
2. Students will use the metric measurement system,
3. Students will save the graph on disk, and
4. Students will add new data to a file.

Materials:

Software: *MECC Graph*
Equipment: 1 Apple/2 students
Other materials: Worksheet: recording data

Before you start:

1. Be familiar with *MECC Graph*.
2. Determine if this activity is restricted to the classroom, the playground, the halls, or the school. Select the objects the students will measure, OR place a restriction on the size of the objects and have the students determine which things to measure (e.g., "length must be between 3 cm and 30 cm long").
3. Make sufficient copies of the worksheet to record the data. Have enough measuring tools (you may want to use the large 1 cm x 5 cm paper clip as the measuring unit).
4. Determine the pairs of students who will work together.

Lesson: (Sequence of instructional activities)

1. Pair the students and hand out worksheet for recording data, Sizing Up Our World.
2. Review with the students which items are to be measured and in what units.

Sample A: BIG THINGS(metres & cm)

Width of classroom
Length of classroom
Distance to the office
Length of blacktop playground
Size of doorway
Tables in the cafeteria

Sample B: LITTLE THINGS (cm only)

Length of second joint on index finger
Length of pencil (new or used)
Disk top length
Disk top width
Height of bike rack
Paper clips

3. After the data is gathered, have students present a list of things in ascending or descending order.
4. After the list is in the correct order, students present the information on *MECC Graph*.
5. The information is then saved on disk and printed out (optional).
6. Next, add two new objects to their list. The students must predict where the new objects should be placed on the graph to maintain order before measuring the objects and adding the information to the file.

Follow-up:

1. Have students measure objects at home and bring the data to school to be graphed.
2. Have students design their own metric house. They can design it in metres and make a cardboard or graph paper layout in centimeters.

4.3
SESSION 3: SPREADSHEETS

4.3.1. Narrative Overview

The first two sessions focused on the use of computers to draw graphs. All math teachers are experienced in drawing graphs by hand. Thus, the transfer to using a computer to draw graphs is relatively easy. Learning theory describes this as "near transfer." Computer graphics was chosen as the topic for the first two inservice sessions because of this near transfer. We didn't want to have participants be faced simultaneously with the task of learning the mechanics of using a computer and learning a new subject area (such as spreadsheets, which are introduced in this third session.)

Spreadsheets are a whole new ball game. Relatively few math teachers have a solid background in accounting or bookkeeping. Many have not previously encountered a paper-and-pencil version of anything akin to a spreadsheet. Thus, the topic of spreadsheets is doubly difficult. Workshop participants must learn both how to use spreadsheet software and what its uses might be in mathematics. Learning theory describes this as "far transfer."

One of the most important concepts in spreadsheets is that of developing a spreadsheet model to solve or help solve a particular category of problem. In essence, this process is a type of mathematical modeling. This suggests a third difficulty for many inservice participants. They may have poor skills in mathematical modeling (in translating real-world problems into mathematical problems) and relatively little experience in teaching mathematical modeling. (Refer back to the four-part diagram from the first session's Game of the Week, which helps clarify modeling and unmodeling versus other aspects of mathematical problem solving.)

For all of these reasons, many math teachers encounter difficulties as they begin to study spreadsheets. The inservice facilitator can decrease the difficulties by using some of the techniques which follow:

1. Check to see which inservice participants have had previous experience with spreadsheets and/or accounting. Pair up these participants with those who lack such a background.

2. Select problem examples that do not pose a difficult mathematical modeling challenge. That is, pick examples and exercises that present a minimal mathematical challenge. (Remember, some of the participants do not have a strong math background. Right now you want them to orient their learning energies to learning about the use of spreadsheets, rather than learning mathematical modeling. But be aware that spreadsheets can help create an excellent environment for teaching mathematical modeling.)

3. If possible, begin by using a simplified or very restricted spreadsheet system such as *Formula Vision*. Participants can experience immediate success in using such software, and they can begin to learn some of the features found in full-blown spreadsheet systems.

4. Move slowly, using lots of examples. Do not expect participants to master spreadsheets in the time devoted to this topic. (Even if two or three full sessions are devoted to spreadsheets, most participants will only scratch the surface of this topic. Spreadsheets are a powerful aid to problem solving. Mastering spreadsheets involves mastering a number of mathematical modeling and problem-solving ideas.)

5. If some participants have used spreadsheets in their teaching or for other purposes, have them give testimonials. This will help other participants to see that it is possible and useful for math teachers to learn to use spreadsheets.

6. Give careful consideration to spending more than one inservice session on spreadsheets. There is enough material included here for two sessions, and the topic of spreadsheets in mathematics could easily use more than two session.

One way to think about a spreadsheet is as an extension of a calculator. A spreadsheet can store both numerical data and formulas. It can automatically perform calculations (following the formulas) on the numerical data. Thus, many of the issues that arise as one considers effects of calculators on the curriculum come up again with the use of spreadsheets. It is important to point out this analogy and to keep raising the issue of what constitutes a good mathematical education for life in a world in which both calculators and computers (including spreadsheets) are readily available.

Math teachers have little trouble thinking of applications of computer graphics in the math curriculum. But many have trouble thinking of possible uses of spreadsheets. Thus, the spreadsheet sessions should devote quite a bit of time to discussing possible applications and the implications of such applications. One key topic for discussion is that of learning to use a tool versus learning to solve problems *using* the tool. How much emphasis should be placed on each of these areas, either during the inservice or in the math classroom, as spreadsheets are introduced in the math curriculum?

The first activity is a brief, usually oriented introduction to spreadsheets. Next, the participants work on *Formula Vision*, an easy-to-use spreadsheet program. They solve several problems and become familiar with some applications of this program.

The second activity is an introduction to the spreadsheet program in AppleWorks. Note that you are introducing participants both to a sophisticated integrated software package and to one particular application program in that package. Keep in mind that this combination may overwhelm some (perhaps most) participants. Entire courses are given on the use of a spreadsheet such as the one in AppleWorks.

If some participants become overwhelmed by the topic, you may want to discuss how students feel when they are overwhelmed by what they are expected to learn. Reassure participants that as they continue to work with spreadsheets, they will eventually begin to feel comfortable with this topic.

4.3.2 Script

Theme

Using spreadsheets in a math instructional setting

Objectives

1. Introduction to the structure and format of a spreadsheet.
2. Explore spreadsheets in an instructional format.
3. Solve a problem by constructing a simple spreadsheet.

Materials

Software

Formula Vision
AppleWorks (AW)
(or some other spreadsheet)
Other
Transparency of spreadsheet
Large butcher paper drawing of a spreadsheet

Handouts

Millionaire spreadsheet
Fast Food Heaven Exercises
Matrix Multiplication
(PA) How to load Appleworks
(AW) screen display for all three of the above (WS)

Refreshments

By now you should have the details of this well established.

Assumptions

It is assumed that many participants will not know the basics of loading *AppleWorks*. If this is the case, explain (PA) how to get files from the disk and save to the disk. If possible, pair up nonusers of *AppleWorks* with participants who have used it before.

Pre-Class

Formula Vision and Fast Food display should be loaded for participants to use when it is time to do so, or placed by the machines along with a Performance Aid so participants can get started by themselves. You may want to have participants start on *Formula Vision* as soon as they arrive, or you may want to start the whole class together with a brief discussion of spreadsheets such as is suggested below.

Introduction
5 Minutes
(Butcher paper
Spreadsheet
transparency)

Purpose: Introduce the concept of a spreadsheet and briefly explain the structure of the session. The entire session will be on spreadsheets and their uses in the mathematics class. The first hour will be fairly structured. Unroll the butcher paper showing what a spreadsheet looks like. (Be dramatic!)

1. Discuss the columns, rows, and labeling.
2. Explain that a cell is named by its row and column intersection.
3. Explain that most spreadsheets can be thought of as having an indefinite number of rows and columns.

Overhead transparency of spreadsheet.

- Describe the movement of the cursor in a spreadsheet.
- Explain entering and deleting information.

Activity
15 Minutes

Purpose: Participants use spreadsheets in an instructional context with a minimal number of instructions. Have participants work in pairs in exploring the Fast Food (*Formula Vision*) spreadsheet.

Fast Food Heaven
Exercises

- Work with the Fast Food Heaven Exercises. Give minimal instructions. (Some of the problems on the WS have multiple answers; these may lead to later problems without solutions.) After about 10 minutes ask participants to think about the various skills they are using (e.g., mental math, estimation, pencil and paper).

Discussion
2-4 Minutes

Debrief the activity. Was it stimulating and/or motivating? Why?

Activity

20 Minutes
Millionaire (WS)

In pairs, have participants play with the Millionaire (*Formula Vision*) template using the WS. They will have to change the labels and formula for this worksheet.

Give as few instructions as possible. Once they solve the first problem, have them try others. Change one or more of the variables. What if the interest is compounded every day, every hour, minute, second?

During the activity ask the normal types of questions:

- Are they enjoying the activity?
- What skills are they using?
- Could this or a similar activity be used in their classroom?

Discussion
2-4 Minutes

Debrief the activity.

Break

10 minute break. Load *AppleWorks* into computers.

Debrief
10 Minutes

Debrief Game of the Week.

Demonstration
15 Minutes
(Omit if time is problem.)

Purpose: Explain the very basic steps needed to construct a spreadsheet. You will want to introduce the vocabulary of labels, values, and formulas. After this explanation they will construct a their own simple one.

Demonstration:
(Omit if there is
a problem.)

Pick a problem from a word problem worksheet and have the class discuss:

1. How the problem can be solved.
2. How to construct a simple template using a spreadsheet.

Example:

Problem 1. Cy had 35 problems for homework. He received $.10 for each correct answer and was fined $.05 for each incorrect answer. Today Cy did 10 problems correctly and had 25 wrong answers. How much did Cy earn or lose? Suppose that all you knew was that Cy earned $1.00; how many did he get correct? (Note that such a problem has many solutions.)

One possible spreadsheet template to use on this problem is:

	A	B	C	D
1	# Probs. =			
2				
3	# Right =		# Wrong =	(B1 - B3)
4	Amount =	((.1 *B3)-(.05*D3))		

Activity
20 Minutes
(Omit if time is a problem.)

The above is one of many possible templates. The important part is solving the problem and discussing how it can be put onto a spreadsheet. Depending on the skill level and background of the participants, the presenter chooses one (or both) of the following:

1. Participants duplicate the above and find an answer.
2. Participants pick one of the other problems and construct a spreadsheet template.

Debrief

During or after the activity ask the same types of questions mentioned earlier. What types of improvements could be made to the spreadsheet? Some participants may be writing their guesses and computer responses on paper. Would it be helpful if the spreadsheet was made into a table so that all the guesses and responses could be reviewed? It is possible using the replicate function. But this a more advanced spreadsheet topic. How could this be used in problem solving? Can it change or present new opportunities for some of the things we teach in mathematics?

Closure
10 Minutes

Teachers are now using spreadsheets in their classroom.

- Rick Thomas in Eugene, Oregon, developed a pre-algebra class that uses spreadsheets. The classroom has five computers, and students use them during class. They also have access to the computer lab. Rick is the author of *ClassWorks*, a complete course on *AppleWorks* for secondary school students. It is published by ICCE and sold on a school site license basis which includes templates, sample tests, overheads, etc.

Depending on time available, there can be discussions on where and how to use spreadsheets. Also discuss possible project ideas. (See Pat Lyon's spreadsheet unit for an example.)

Collect Logs

Game of the Week

Identify a strand in your curriculum where it might be appropriate to use spreadsheets. Develop templates for *Formula Vision* or a full blown spreadsheet that could be used to help solve some of the types of problems encountered in the unit.

4.3.3 Timeline

Have *Formula Vision* disks with appropriate data file available at the computers. The participants should load the program and begin working with it as soon as they arrive at the inservice. A large screen monitor or projection system is needed for this session.

0:00-0:15	Activity 1. Fast Food Worksheet and *Formula Vision*. Have participants try all the questions.
0:15-0:24	Debrief. Was it easy to load and go? Were the worksheet problems easy to solve? What steps did they take in solving the problem(s)? What did they write down and how did they use the computer? Short explanation of spreadsheet terminology and use.
0:24-0:44	Activity 2. Millionaire Worksheet and *Formula Vision*. Let participants work to solve the first problem and continue with the extra problems if time permits.
0:44-0:48	Debrief. Was this any different from the other worksheet? Was it easier? Harder? Would they have used a computer if they had the choice?
0:48-0:58	Break. Collect logs and Game of the week, and load *AppleWorks*.
0:58-1:08	Debrief Game of the Week.
1:08-1:23	Demonstration of *AppleWorks* on large screen monitor or projection system.
1:23-1:45	Allow participants to use *AppleWorks* to solve the Millionaire worksheet. Then let the "novices" do something similar to the worksheet while the "experts" can work on either matrix multiplication or the continuation of the Millionaire worksheet. Another option is to pair up the experts with novices and let the experts become the teachers.
1:45-2:00	Debrief the activity. Is *AppleWorks* easier or harder than using *Formula Vision*? Why? What are some of the similarities and differences between the two pieces of software? What seems to be hard about learning to use spreadsheets, and what is not so hard? Announce Game of the Week. Remind participants where we will meet next week and to complete log sheets. Encourage participants to do the Game of the Week. *Talk to five people about being "experts" for next week's session. It will be on problem-solving software. Try to get different volunteers than last time that there were a number of workstations staffed by volunteers. Have the software available to loan to these volunteers.*

4.3.4 Handouts

These handouts are needed during Session 3. The facilitator may want to make some of these into overhead projector foils for use during the inservice.

In preparing these materials for publication, the authors were faced by the problem of how to deal with data sets or templates containing data that needs to be available to the participants. In the case of Lucy Van Pelt (see Session 1) we asked the reader to create a suitable database. In the current session we ask the reader to create files to fit the data for the exercises. This is relatively easy to do. The *Formula Vision* spreadsheet has exactly 15 cells. Each cell can contain a label (the name of the cell), a number or formula, and a unit of measure. For example, a cell might contain the label RATE, the value 15, and the unit MPH (miles per hour).

The first exercise for this session uses *Formula Vision* with a template (worksheet) containing the 14 food items and their prices given in the Fast Food Heaven Menu on page 3 of this section. The 15th cell is labeled TOTAL. You will want to name the template (worksheet) **Fastfoods**, as that is the name that has been used in the Performance Aid on page 2 of this section. The Performance Aid on page 5 may be of help in learning to create a worksheet.

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Introduction to *FORMULA VISION*

[*Note: This is a Performance Aid. It is a detailed set of directions for accomplishing a specific task with a particular piece of software.*]

1. Insert the *Formula Vision* disk into the disk drive, with Side A up. (Be sure to close the drive door.)

2. If the computer is off, turn it on. If the computer is already on, hold down the **Open-Apple** and **Control** keys, and press the **Reset** key (this is called a *warm start*). When you release these keys, the disk drive should start and the program will load. (If it doesn't work, repeat this step.)

3. Notice the instruction "Please press spacebar to continue" at the bottom of the screen. Follow that instruction.

4. You will see a menu with four different selections. Read the menu and then press **1** in order to "Go directly to *Formula Vision*."

5. Read and follow the instructions at the top of the screen that direct you to remove the *Formula Vision* disk from the drive, turn it over, and insert it back into the drive. (Be sure to close the drive door.) Then press the **spacebar** to continue.

6. Notice that you now have a 15 cell grid consisting of five rows of three cells each. We will now tell you how to type a Label, Value, and Unit into two different cells, and then how to type a Label and Formula into a third cell. We will be working with the formula for the area of a rectangle:

   AREA = LENGTH * WIDTH

   We will compute the area of a rectangle whose length is 8 inches and whose width is 6 inches. Then you will be given the chance to experiment with other values and formulas.

7. Type the word LENGTH and then the **Return** key followed by the **Down Arrow** key. (Notice that the Label LENGTH is now in the top of a cell.)

8. Type the number **8** and then the **Return** key followed by the **Down Arrow** key. (Notice that the Value 8 is now in the middle of the cell.)

9. Type the word INCHES and then the **Return** key followed by the **Down Arrow** key. (Notice that the Units, IN for inches, is now in the bottom of the cell.)

10. Repeat the steps 7-9 above, but this time type WIDTH for the cell Label, 6 for the cell Value, and INCHES for the cell Units.

11. Next type the word AREA and then the **Return** key followed by the **Down Arrow** key. (Notice that the Label AREA is now in the top of a cell.)

12. Type the formula LENGTH * WIDTH and then the **Return** key followed by the **Down Arrow** key. Be sure to use the asterisk to indicate multiplication. Later you may want to experiment with other symbols that you think might indicate multiplication. (Notice that what you type does not appear in the cell. Instead, the computer follows the directions specified by your formula, computes 48 as the answer, and displays it in the cell. Notice also that the computer indicates that the Units are square inches.

13. Now experiment, using different Values. Notice that as soon as you change a Value, the area automatically is recomputed. Try changing the Units in one of the cells; for example, change 6 INCHES to 6 MILES. Notice how the computer indicates that you have mixed units, and that therefore you have done something wrong.

14. Continue to experiment by trying a different formula. Notice that there are enough cells so that you can have several different formulas displayed at one time. What happens if you attempt to use the Label from one cell as the Label for another cell?

15. Continue to experiment by trying some of the menu items at the top of the 15 cell display.

Formula Vision: Fast Food Heaven

[*Note: This is a Performance Aid. It is a detailed set of directions for making use of the Formula Vision software and the Fast Food Heaven data to get started on solving some of the Fast Food Heaven Exercises.*]

1. Put the *Formula Vision* disk into the disk drive, label side up. Close the disk drive door and turn on the machine. If the computer is already on, put the disk in the disk drive and close the drive door. Then hold down the **Control** and **Open Apple** keys and press the **Reset** key.
2. Once *Formula Vision* is on the screen, press the **space bar**. Select the **number 1** and follow directions.
3. Once *Formula Vision* is loaded, a 3 x 5 spreadsheet will appear on the screen.
4. To open the **Files Menu** in order to get the Fast Foods file, hold down the **Control** key and press the **F** key.
5. The numbers 0 through 7 will appear, along with a description of what each number will do. You want #1. Use the **down arrow** key to move the cursor to **#1** and then press the **Return** key.
6. Get the worksheet named **Fastfoods** (type it in; after the third letter, the name should appear). Press the **Return** key.
7. The **Fast Foods** worksheet will be on the screen. Using the **arrow** keys, move the cursor to the cell named **Total.** The cursor should be right under the name **Total**.
8. You can now use the **menu handout** as well as the screen to determine the guesses you will type in. For example, if you think the first answer is a hamburger, fries, and a small coke, type in H+F+SC. Then press the **Return** key and see what appears in the cell named Total.
9. You can **change** what you want calculated simply by and pressing the **Return** key.

Fast Food Heaven Menu

Sandwiches	**Price**
Hamburger (H)	$1.25
Cheeseburger (CH)	$1.45
Hamburger Supreme (HS)	$1.55
Cheeseburger Supreme (CS)	$1.75
Hot Dog Supreme (HDS)	$1.25

Side Dishes	**Price**
Fries (F)	$ .45
Cole Slaw (C)	$ .55

Drinks	**Price**
Small Cola (SC)	$ .50
Large Cola (LC)	$ .75
Small Diet Cola (SDC)	$ .60
Large Diet Cola (LDC)	$ .80
Milk Shake (MS)	$ .95

Desserts	**Price**
Ice Cream Bar (I)	$ .65
Apple Pie (A)	$ .85

Fast Food Heaven Exercises

Instructions

Look at the menu. For each problem below, decide which items the person bought and type in a formula made by adding the abbreviated names. For example, if you think the person bought a hamburger, fries, and a large cola, you would type H + F +LC in cell 15, the one named TOTAL and press the Return key. The computer will determine the total cost of a hamburger, fries, and a large cola, and will display it in that cell. If it is not the answer you wanted, move the cursor back to cell 15 (the TOTAL cell), type in a formula for your new guess, and press the Return key.

Problems

1. Judi, whose favorite restaurant is Fast Food Heaven, stopped by while cruising last night. She ordered one sandwich, one drink, and one dessert for a total cost of $3.00. What did she order?

2. Seymour, who was introduced to the wonders of Fast Food Heaven by Judi, decided he had to try one item from each of the four categories. He spent $2.95. What did he order?

3. Seymour enjoyed his meal so much that he went back the next day. This time he also ordered one item from each category. Two of the items were the same as the day before and two were different. This time the cost was $3.90. What did he order?

4. Larry, who was very hungry, knew that Fast Food Heaven was just the place to fill up. He spent $5.15 (I told you he was hungry) on five items, which included one dessert and one side dish. What did he order?

Formula Vision: Compound Interest

1. To **clear** the spreadsheet so that you can start writing a new one, hold down the **Control** key and press the **T** key.

2. The numbers 0 through 7 appear along with a description. Use the **down arrow** key to move the cursor to **#1 - Clear the worksheet**. Press the **Return** key.

3. In *Formula Vision*, the mathematical symbols used are:

+	for addition
-	for subtraction
*	for multiplication
/	for division
^	for exponentiation (This symbol is called "carrot" and is the top of the 6 key.)
( )	for grouping

   Formula Vision uses other symbols, but you do not need to know them at this time.

4. Type in the necessary labels, numbers or formulas, and units name for the **Millionaire Worksheet**.

5. Use the **arrow** keys to move around the spreadsheet. If you want to **delete**, simply put the cursor on the desired spot and either **re-type** the information or use the **delete** key. Practice this until you are comfortable in deleting.

6. The formula for interested compounded yearly is:

   T = P * (1 + IntRate) ^ Years

   where T = total, P = principal, and IntRate = interest rate expressed as a decimal equivalent. Thus, 8.6% is expressed as .086. The same general formula holds for more frequent compounding. Thus, suppose one had $12,500 invested at 9% per year, compounded monthly, for 10 years. The computation to be performed is:

   T = $12,500 * (1 + .0075) ^ 120

Here .0075 is .09 divided by 12 (months per year), and 120 is 10 times 12 (months per year).

Millionaire Spreadsheet

1. **Estimation:** Suppose you wanted to have $1,000,000 in the bank exactly 20 years from now. How much money would you need to invest today at 15% interest for 20 years to have one million dollars? The remaining variable is the number of times the account is compounded— that is up to you. It may be yearly, quarterly, monthly, daily, etc.

   Write down your answer here ______________________.

2. **Difficulties:** Note here any difficulties you encountered in using this particular piece of software to solve this problem. Remember, *Formula Vision* is a rather restricted type of spreadsheet software. The problem was chosen to let you encounter various difficulties.

3. **Other applications:** What are some other problems you might solve using this spreadsheet software? Describe some that would be easier to solve **not** using the spreadsheet, and others for which use of the spreadsheet would seem to work best.

Millionaire Worksheet Extensions

The following problems are similar to the Millionaire problem and can be solved using *Formula Vision.*

1. **Comparison Shopping:** Compare interest rates and number of times compounded yearly to get the best possible savings rate. For example: The United Trust Bank offers 8.5% annually and the InterCounty Bank of Hazzard offers 8.25% compounded daily. Which bank offers the best return on your deposit?

2. **Limits:** Hold the interest rate, amount deposited, and number of years constant and change the number of times compounded annually to see the rate of change from yearly interest, compounded biannually, quarterly, monthly, weekly, daily, hourly, every second.....What happens? A graph may be helpful in understanding the results.

3. **Graphing:** Pick an amount of money (such as $1,000) and an interest rate (such as 8%). Determine the amount of money you would have at the end of 5, 10, 15, and 20 years. Now change the interest rate (to 10% for example) and repeat the calculations. Graph the results and discuss what they show about compound interest.

4. **Inflation:** Suppose that the annual inflation rate is 4%. A particular car costs $10,000. Taking into consideration only the inflation rate, what would be the cost of a similar car 50 years from now?—100 years from now? Do the same calculations assuming an inflation rate of 6% per year. Discuss the results.

HOW TO LOAD THE *APPLEWORKS*™ PROGRAM

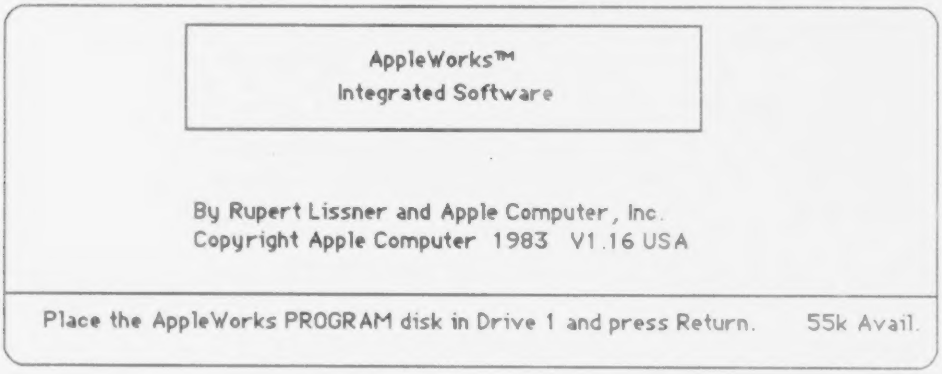
The following pages have been reproduced with permission from ICCE. The pages are taken from *Appleworks™ for Educators* by Linda Rathje, © 1986, pgs. 7-9 and published by ICCE.

The *AppleWorks* program is split into two parts:

Part 1: the "AppleWorks Startup" is on one side of the disk.

Part 2: the "AppleWorks Program" is either on the back side of the disk or on a separate disk.

1. Put the AppleWorks Startup disk in drive 1.
2. Put the data disk, that came with this AppleWorks book, in drive 2.
3. Turn on the monitor.
4. Turn on the computer.
5. If it is already on, hold down the open-apple and CONTROL keys, and tap the RESET key.
6. The COPYRIGHT SCREEN should appear:



AppleWorks™
Integrated Software

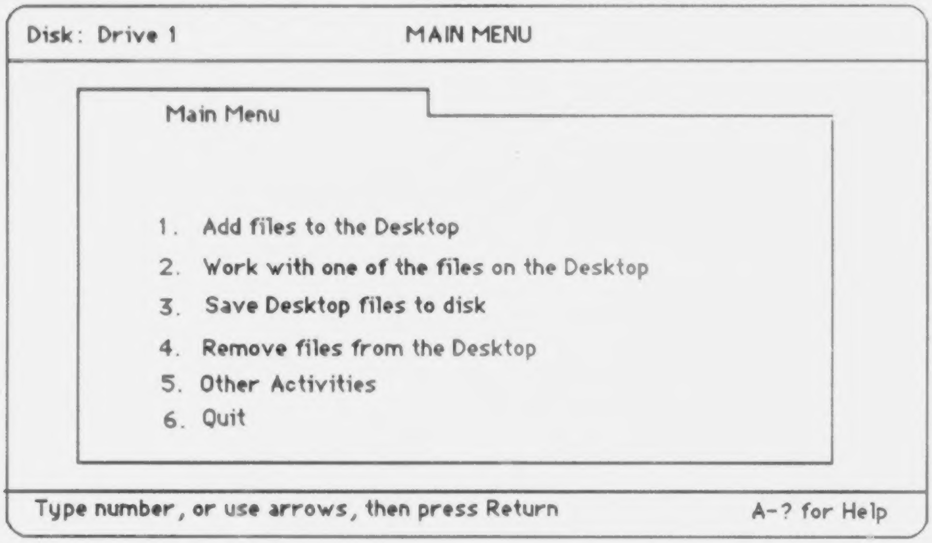
By Rupert Lissner and Apple Computer, Inc.
Copyright Apple Computer 1983 V1.16 USA

Place the AppleWorks PROGRAM disk in Drive 1 and press Return. 55k Avail.

7. Remove the *AppleWorks* Startup disk from drive 1.
8. Insert the Program disk in drive 1, and press RETURN.
9. Type today's date using the form shown on the screen.

10. Press RETURN.

11. The *AppleWorks* MAIN MENU should now be on the screen:



```
Disk: Drive 1                    MAIN MENU

        Main Menu

      1.  Add files to the Desktop
      2.  Work with one of the files on the Desktop
      3.  Save Desktop files to disk
      4.  Remove files from the Desktop
      5.  Other Activities
      6.  Quit

 Type number, or use arrows, then press Return        A-? for Help
```

activity 1 AN INTRODUCTION

PART 1 : HOW TO CREATE A SPREADSHEET "FROM SCRATCH"

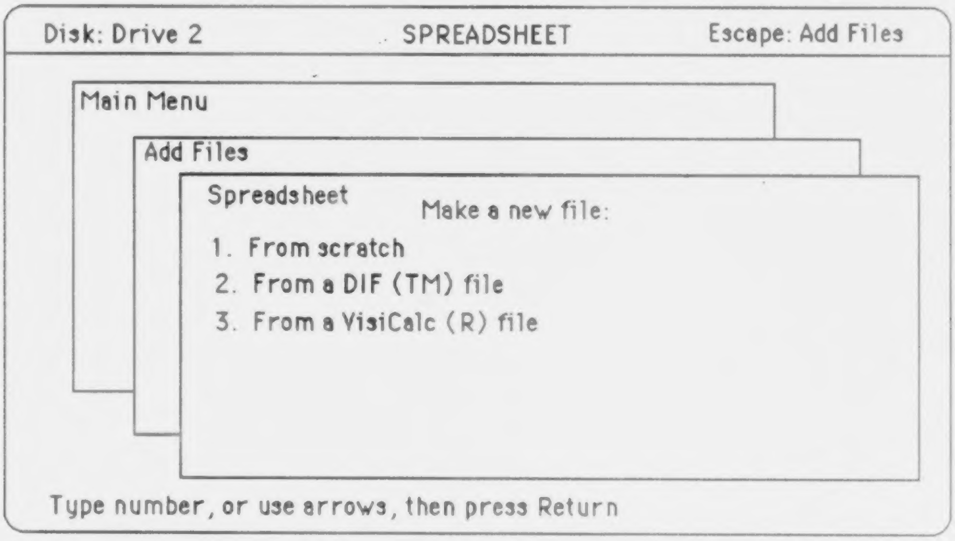
In this activity you will practice entering and changing information in a spreadsheet. The examples are simple and serve as an opportunity for you to become acquainted with what a spreadsheet looks like and what a spreadsheet can do.

NOTE: "Select" means to highlight an option, then press RETURN.

"Enter" means to type in the information. If you make a mistake, use the DELETE key to correct, then press RETURN to confirm.

1. Begin at the Main Menu.
2. Select : 1. Add files to the Desktop press RETURN
3. Select : 5. Make a new file for Spreadsheet press RETURN
4. Select : 1. From scratch press RETURN
5. Note the blinking cursor at the bottom of the screen.
6. For filename, type: SS PRACTICE press RETURN

Each time a new menu selection is made, another menu appears on the screen. Your screen should now display the "Spreadsheet" menu, which is overlaying the "Add Files" and "Main" Menus:



Disk: Drive 2 SPREADSHEET Escape: Add Files

Main Menu

Add Files

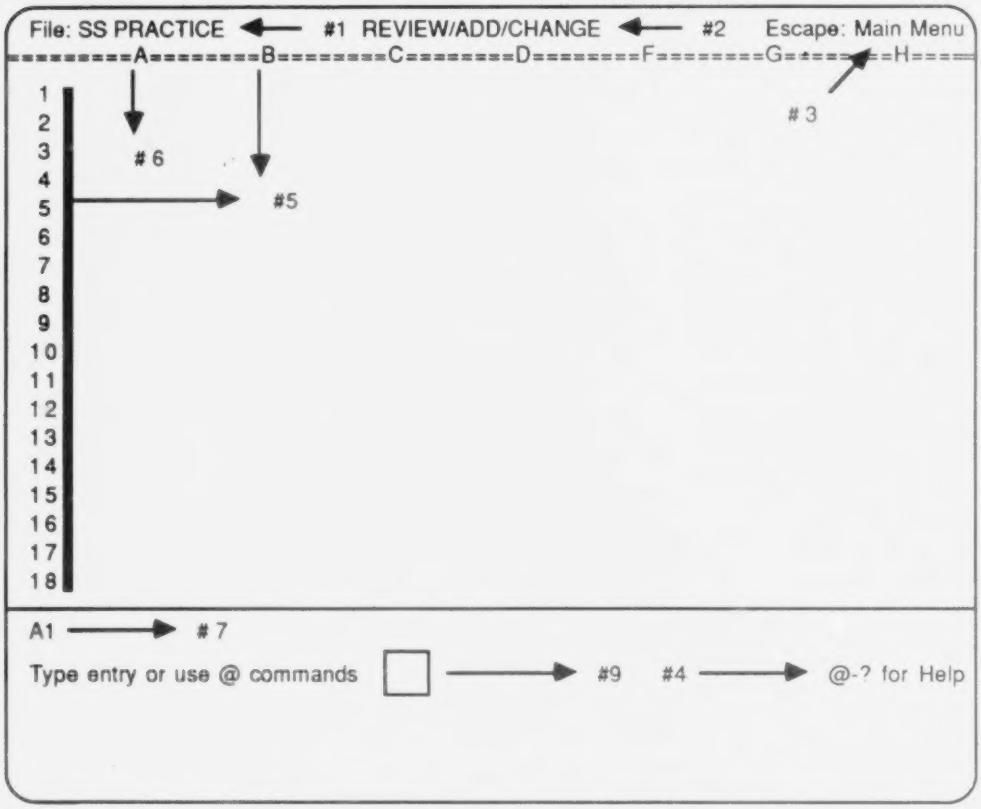
Spreadsheet

Make a new file:

1. From scratch
2. From a DIF (TM) file
3. From a VisiCalc (R) file

Type number, or use arrows, then press Return

7. Press RETURN.
8. An "empty" spreadsheet should now be on the screen:



```
File: SS PRACTICE          REVIEW/ADD/CHANGE          Escape: Main Menu
=========A========B========C========D========F========G========H====
 1
 2
 3
 4
 5
 6
 7
 8
 9
10
11
12
13
14
15
16
17
18

A1
Type entry or use @ commands                              @-? for Help
```

#1. The name of your spreadsheet file ("SS PRACTICE").

#2. The screen heading indicates a section of the *AppleWorks* program. On this screen you can review, add, or change information.

#3. This screen heading indicates which section of the program will be displayed if you press the ESC key.

#4. A reminder that pressing the Open-Apple and question mark keys will display a Help screen.

#5. Rows and columns divide the spreadsheet into a grid pattern on the screen. COLUMNS are identified by letters. ROWS are identified by numbers.

#6. The highlighted bar on the screen is the spreadsheet CURSOR and indicates your place within the spreadsheet grid. The CURSOR is in column A, row 1—its position is referred to as CELL A1.

#7. The CELL INDICATOR gives the cell number of the cursor's position. As you enter information for a cell it will first appear in the space BELOW the cell indicator (see #9).

#8. The spreadsheet PROMPT. Instructions for working with the spreadsheet appear in this area.

#9. The blinking cursor indicates where labels, values, formulas, or *AppleWorks* commands are entered. Your typing appears at this cursor.

Fast Food Heaven AppleWorks Problems

Instructions

There are two possible approaches to this set of problems. First, the inservice facilitator might create an *AppleWorks* spreadsheet template containing the information from the Fast Food Heaven Menu (page 3) and in a format designed to help solve the types of problems given here. Alternatively, if sufficient instruction has been given on spreadsheets, participants might create their own templates.

One approach to developing a useful template is to use one column for the names of the food items, a second column for the costs of the food items, a third column for the number of each item purchased, and a fourth column for the products of numbers of items (from the third column) times their costs (from the second column). The total cost of a purchase is then found by a summation on the fourth column.

The user of this spreadsheet then enters a sequence of numbers into the third column, representing the number of each item purchased. This actually is a quite awkward approach, since it is necessary to have zeros in the cells where none of the item is being purchased. While the spreadsheet can initially have zero's in all of those cells, once one purchase has been processed, that will no longer be the case. Thus, in solving the problems given below by trial and error, the user will have to spend quite a bit of time indicating that "zero" of particular food items were purchased.

The *AppleWorks* spreadsheet can be set so that it automatically recalculates after each change to a cell, or so that it recalculates only when directed to do so. The instruction for recalculating is to hold down **Open Apple** and press the **K** key.

Problems

1. Judi, whose favorite restaurant is Fast Food Heaven, stopped by while cruising last night. She ordered one sandwich, one drink, and one dessert for a total cost of $3.05. What did she order?
2. Seymour, who was introduced to the wonders of Fast Food Heaven by Judi, decided he had to try one item from each of the four categories. He spent $3.30. What did he order?
3. Seymour enjoyed his meal so much that he went back the next day. This time he also ordered one item from each category. Two of the items were the same as the day before and two were different. This time was $3.20. What did he order?
4. Larry, who was very hungry, knew that Fast Food Heaven was just the place to fill up. He spent $4.60 (I told you he was hungry) on five items which included one dessert and one side dish. What did he order?

Game of the Week

The essence of a spreadsheet is that it is a piece of software designed to allow one to develop certain types of mathematical models, and to have the computer carry out the computations indicated by the model. Thus, a spreadsheet is useful when the type of problem under consideration can be modeled (represented) using a spreadsheet, and the amount of computation to be done is relatively substantial.

Think about the math courses that you teach. Select a strand or unit in a particular course where you think a spreadsheet might be a useful tool. Describe some of the types of problems that one studies in this unit. Discuss how a spreadsheet would be useful in solving these types of problems.

Next, select a strand or unit where you feel a spreadsheet would not be a useful and appropriate tool. Describe the types of problems encountered in this unit, and explain why a spreadsheet would not be a useful tool in dealing with these types of problems.

Game of the Week Outcomes

[Note: This is not intended as a handout. Rather, it is a brief discussion to give the inservice facilitator some ideas on what outcomes may be expected from the Game of the Week.]

Find a strand in your curriculum where you can use spreadsheets.

Answers we received:

- recording grades
- perimeter, area and volume of polygons
- decimal unit
- gathering and sorting data
- equivalent fractions
- number patterns
- percents
- probability and statistics - frequency distribution
- accounting
- solving equations
- mean, median, mode and standard deviation

Many teachers stressed the need for hardware and the availability of software. If these problems were taken care of, they saw time in the curriculum to explore "What if ..." type problems and more time for problem solving and working on the understanding of where and how to use the math the students have learned in "real life."

One of the most common uses of spreadsheets was to keep grades, either by the teacher or by the students. One teacher suggested a print out of all the students' grades and blanks to fill in. Then they could work out what they needed to fill in the blanks with in order to achieve the grade they desired!

A spreadsheet is a very powerful aid to modeling and solving certain types of problems. But much of the math curriculum focuses on learning a little bit about a lot of ideas, and quite a bit of this learning is at the lower-order skills level. For example, students need to learn the mathematical vocabulary, and they need to learn some formulas such as A = LW. These are lower-order skills, rather than problem solving. Since a spreadsheet is essentially an aid to modeling and solving problems, it is of less use and interest in the lower order skills parts of secondary school mathematics.

4.3.5 Student Materials

These sample lesson plans are designed to be used with students at a variety of grade levels. They represent the types of activities that can be done with students after inservice participants have learned the material in Session 3.

Inservice facilitators will want to use of some these materials during the inservice. If it is more than two hours in length, it is appropriate to have participants work through a number of these student activities.

Index to Materials	Page
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Concession Session	3
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Matrix Multiplication file for AppleWorks	8
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Millionaire File for *AppleWorks*

This is a *MacWrite* file copy of what an *AppleWorks* file should look like for use with the Millionaire worksheet. You will probably want to enter this information into an *AppleWorks* file and not pass this particular sheet out to participants.

```
File: MILLIONAIRE              REVIEW/ADD/CHANGE              Escape: Main Menu
======A=========B===============C=============D==========E======F=====
 1|
 2|                  How To Become A Millionaire
 3|
 4|            Amount at maturity                   $1,035.31      < do not type here
 5|
 6|
 7|=================================================================
 8|
 9|        Amount Deposited              =$      $1,000.00         < Make changes
10|        # times compounded yearly     =#          4             <  here,
11|        # years to maturity           =#           .50          <  here,
12|        Annual interest rate          =%          7.00          <  or here
13|
14|
15|        How much should be deposited
16|        in order to have $1,000,000
17|        at the end of 20 years?
18|
--------------------------------------------------------------------
D4:   (Value, Layout-D2)  (D9*((1+(D12/(100*D10)))^(D10*D11)))
```

Concession Session

Load the spreadsheet file Concession Stand. (A *MacWrite* copy of the file is given on the next page.)

Here is a chance for you to run your own business. This template is a very simple type of simulation. The template consists of two parts. The top part allows the teacher (the person setting up the simulation) to enter the prices the supplier charges. The student then decides how many of each item to purchase. The Total Cost for each item and the Total for all Purchases are automatically calculated.

In the bottom portion of the spreadsheet the student is allowed to entered the prices that the Concession Stand will charge. The Gross Amount and Profit for each item are calculated automatically, as well as the Total Profit and Net Profit. Here are the steps for running the Concession Stand:

1. You must decide how much you wish your supplier to charge! In the top portion of the spreadsheet, enter the prices and the number of items you wish to buy from your supplier.
2. In the bottom portion of the spreadsheet, decide how much the customers will be charged and enter the values in the Price column. Next, enter the number of items you sold (or hope to sell).
3. Play with the various possibilities. Ask yourself "What if questions. Is there a way of "beating" the simulation?

Extensions

1. In the classroom this could be extended by making use of random events through the use of cards or dice. Events such as how many of an item sold, weather, a short game, an extra inning game, rival businesses, etc., could all be decided randomly. Divide the class into groups and have them compete against each other.

2. Design your own business simulation.

3. Use this software to keep track of the inventory of a school store.

Concession Stand File for *AppleWorks*

[*Note: This is a* MacWrite *file copy of what an* AppleWorks *file would look like for use with the Concession Session activity*.]

```
File:  ConcessionStand            REVIEW/ADD/CHANGE          Escape:  Main Menu
======A==========B======C=========D========E=======F=====G========H=====
                                  Concession Stand
  1|
  2|
  3| You are in charge of the concession stand at the baseball games.
  4|  Below is a list of items that you need to buy to be prepared for
  5|  the next game.  First you must decide how many of each item you
  6|  need to purchase.  Second you will have to decide how much to charge
  7|   your customers so that you will be able to make a profit.
  8|
  9|                                  Supplier's Prices
 10|   Item        Price   # Bought       Total Cost        Total for all Purchases
 11|   Hot Dogs     $.30     100            $30.00
 12|   Peanuts     $0.00       0             $0.00
 13|   Ice Cream   $0.00       0             $0.00
 14|   Cokes       $0.15     400            $60.00
 15|   T-Shirts    $0.00       0             $0.00
 16|   Napkins
 17|   per 100     $0.00       0             $0.00
 18|   Total cost for all items purchased.                          $90.00
 19|   Fill in below the prices you will charge
 20|                     Your Prices
 21|   Item        Price   # Sold         Gross Amt         Profit on # Sold
 22|   Hot Dogs     $.75      80            $60.00                   $36.00
 23|   Peanuts     $0.00       0             $0.00
 24|   Ice Cream   $0.00       0             $0.00
 25|   Cokes       $0.50     300           $150.00                  $105.00
 26|   T-Shirts    $0.00       0             $0.00
 27|   The paper supplies are a fixed cost.  You
 28|   make no profit from them.
 29    Total income                                                $141.00
 30                                           Net Profit on Today's Game
 31
 32                                                                 $51.00
-----------------------------------------------------------------
G22:   (Value, Layout-D2) +G29-G18
```

Go Soak Your Head
(Archimedes Lives!!)

Introduction

This simple spreadsheet (see page 6 of this section) helps calculate the *approximate* volume of a head. Since human heads rarely follow the Platonic Ideal, students are asked to measure a head using two different geometric approximation models. One is for well-rounded individuals, using a cylinder as a model; the other uses a rectangular solid. (The more scientifically-inclined student can actually find the volume of his or her head by submerging it in a bucket of water and measuring the amount of displacement. Archimedes would be overjoyed!)

Cells E15 (formula for volume of cylinder) and E22 (formula for volume of rectangular solid) are protected to prevent destruction. The user of this spreadsheet enters height and radius of a head into cells D18 and D19, and length, width, and height of a head into cells D26, D27, D28. Then when the spreadsheet is recalculated, the two volume estimates will be in E15 and E22.

Activities and Extensions

1. Measure or estimate the dimensions of your own head and enter the results. (If you wish to go soak your head, please consult with your teacher.)
2. Think of some other geometric solids a head might resemble. A cube? Tetrahedron? Pyramid? Find the formulas for their volumes and add them to the spreadsheet.
3. How could the spreadsheet be made into a table form so that all the students in the class could add their own dimensions to it? Would it make sense to take an average of the head measurements of class members?
4. An activity that uses smaller utensils and measuring devices would be to find the volume of a finger or of the whole hand. What measurements would be needed? How could the spreadsheet be laid out for an individual or for the entire class?

Archimedes Lives File for *AppleWorks*

This is a *MacWrite* file copy of what an *AppleWorks* file looks like for use with the Go Soak Your Head worksheet.

```
File:  Go Soak Your Head       REVIEW/ADD/CHANGE                  Escape:  Main Menu
======A=======B======C========D=======E======F====G======H========
  1|                          GO SOAK YOUR HEAD
  2| This is a program to help calculate the volume of your head from two
  3|  perspectives.  The head, unfortunately, is not shaped uniformly for easy
  4|  mathematical calculations.  The first part of this program treats the
  5|  head as a cylinder and the second part as a rectangle.  Measure a head
  6|  and enter the results.  The program will automatically calculate the
  7|  volume.  Then get a large bucket and fill it to the rim with water.
  8|  Place the bucket inside a large pan.  Submerge your head completely.
  9|  Then measure the overflow and you will have the volume of your head.
 10|
 11| Which of the measurements below comes the closest?  Is the average
 12| of the two measurements closer?
 13|
 14|  Volume          Area of Base
 15|     of      =        times              =  0
 16|  Cylinder        Height of Cylinder
 17|
 18|  Height of Head          =               0
 19|  Radius of Top of Head   =               0
 20|
 21|  Volume
 22|     of      =   Length times Width         =           0
 23|  Rectangular        times Height
 24|  Solid
 25|
 26|  Length of Head          =               0
 27|  Width of Head       =         0
 28|  Height of Head          =               0
--------------------------------------------------------------------------------
E22:  (Value, Protect-N)  (D24*D25*D26)
```

Matrix Multiplication

Load the template entitled MatrixMult given on page 8 of this section.

1. Displayed is an example of two 3 by 3 matrices and their product. Enter two new matrices. The product will automatically be calculated as you enter the new matrices.
2. Is matrix multiplication commutative? That is, is A x B = B x A for all matrices? Try a couple of 3 x 3 examples and make a conjecture as to the answer.
3. What is the multiplicative identity element? Check your idea.
4. Change the existing template or make a new template to multiply 2 x 2 matrices. Test your results on several problems until you are convinced that your template is correct.

Matrix Multiplication File for *Appleworks*

This is a *MacWrite* file copy of what an *AppleWorks* file would look like for use with the Matrix Multiplication worksheet.

```
File:   MatrixMult              REVIEW/ADD/CHANGE            Escape: Main Menu
=======A========B=======C======D======E========F=======G=====H====
  1|                    Matrix Multiplication
  2| From Mathematical Applications of Electronic Spreadsheets
  3|                     by D. E. Arganbright
  4| The following is for multiplying two 3 by 3 matrices.
  5| Enter your values into matrices A and B.
  6|
  7|                  Matrix A                        Matrix B
  8|
  9|      1        2        3               4        6        9
 10|      2       -8        0               3        1        0
 11|      3        0        1              -3       -1        1
 12|
 13|                            Product
 14|                        1        5       12
 15|                      -16        4       18
 16|                        9       17       28
 17|
----------------------------------------------------------------------
```

The following are the formulas used for each cell to solve the matrix multiplication problem.

(A9*E9)+(B9*E10)+(C9*E11) (A9*F9)+(B9*F10)+(C9*F11)
(A9*G9)+(B9*G10)+(C9*G11)

(A10*E9)+(B10*E10)+(C10*E11) (A10*F9)+(B10*F10)+(C10*F11)
(A10*G9)+(B10*G10)+(C10*G11)

(A11*E9)+(B11*E10)+(C11*E11) (A11*F9)+(B11*F10)+(C11*F11)
(A11*G9)+(B11*G10)+(C11*G11)

Projectile Motion

(How long is it actually going up?)

1. Load the PROJECTILE spreadsheet file given on page 11 of this section.
   a. Read the directions in the spreadsheet.
   b. Note that the initial velocity for the projectile is entered into cell C9.
   c. Use the Table B(see page 10 of this section) to record the results of your investigations.

2. What initial velocity is needed for the projectile to attain a maximum height of approximately 200 feet? (Use guess and check methodology to solve this problem.)
   a. What velocity did you start with? Were you high or low?

   b. How long did it take to reach this height?

   c. What do the negative numbers in the height column mean? Are they important?

   d. How does a change in the initial velocity effect the rate of change of height?

   e. When is the rate of change of height increasing? Decreasing?

   f. When is the rate of change of height greatest? Least?

   g. What does a positive rate of change of height indicate? A negative rate of change?

3. What initial velocity should be used if the projectile is to reach its maximum height in exactly 2.5 seconds?

4. Play with the spreadsheet and pose problems of your own.

5. Graph some of the results of your explorations.

Projectile Motion Tally Chart

Velocity:

Initial Time:

Time Increment

Time	Height	Rate

Velocity:

Initial Time:

Time Increment

Time	Height	Rate

Projectile File for *Appleworks*

This is a *MacWrite* file copy of what an *AppleWorks* file would look like for use with the Projectile Motion worksheet.

```
File:  PROJECTILE              REVIEW/ADD/CHANGE                    Escape:  Main Menu
======A========B========C=========D==========E======F====G======H=

  1|                          PROJECTILE MOTION
  2|                          suggested by Don McNair
  3|
  4| The spreadsheet will calculate the height and rate of change of a
  5| projectile.  Enter the initial velocity, the initial time, and the
  6| time increments you wish to observe.  Each time you wish to see the
  7| effect of the values, enter  Open Apple K  (for Kalculate).
  8|
  9|           Velocity          =    1100          Formula: h(t) = vt - 16t^2
 10|           Initial Time      =       0
 11|           Time Increment    =     0.5
 12|           (enter Open Apple K)
 13|                                                     RATE OF
 14|           TIME                  HEIGHT              CHANGE
 15|           0                        0                   0
 16|           0.5                     46                  92
 17|           1                       84                  76
 18|           1.5                    114                  60
 19|           2                      136                  44
 20|           2.5                    150                  28
 21|           3                      156                  12
 22|           3.5                    154                  -4
 23|           4                      144                 -20
 24|           4.5                    126                 -36
 25            5                      100                 -52
 26            5.5                     66                 -68
 27            6                       24                 -84
 28            6.5                    -26                -100
 29            7                      -84                -116
```

4.4
SESSION 4: PROBLEM SOLVING

4.4.1 Narrative Overview

Problem solving is now considered to be a major focus and central theme both in mathematics and in all other academic disciplines. The back to basics movement of the past two decades is now being countered with a problem solving movement. In essence, our educational system is struggling to find an appropriate balance among the lower-order skills and the higher-order skills in Bloom's taxonomy. The majority of educational leaders feel we moved too far toward the lower-order skills during the past two decades, and now recommend moving toward the higher-order skills.

Problem solving tends to have a variety of meanings even in math education. If time permits, it is an interesting exercise to have inservice participants write down their own short definitions of problem solving. Then debrief, first in triads and then in the whole group. You may find that few participants can give a reasonably comprehensive definition of problem solving! If so, refer them back to Section 2.2, Role of Computers in Problem Solving, and to the Game of the Week in Session 1, which contains the four-part math problem-solving model discussed in the first of these math inservices. As you may recall, most math educators estimate that the math curriculum spends 70% to 80% of its time teaching students to do things by hand that a computer or calculator can do.

It is generally agreed that one of the main goals in math education is to increase students' math problem-solving skills. In addition, most math educators agree that students should learn to apply their math problem-solving skills to math-oriented problems in other disciplines. But this turns out to be a major difficulty. For example, many students will study metric measurements in a math class and demonstrate competence through their performance on a test. They will then go into a science class and display complete ignorance of metrics!

Learning theory talks about *transfer* of learning. The transfer of metric knowledge from a math class to a science class is difficult for many students. But research on learning theory suggests that transfer can be increased by appropriate *teaching for transfer*. One main thrust of this inservice session is to discuss the question of transfer and how to help increase it. One good way to start this session is to briefly discuss the topic and then ask participants to write down some examples of what they do to facilitate transfer. Debrief in triads and in the whole group.

There are many pieces of problem-solving software available. Participants will have the opportunity to use several pieces of software during this inservice session. Generally, the problem-solving software has been designed in a game format and is fun to use. Fundamental questions include:

1. What does a student learn about problem solving by using the software?
2. To what extent does the knowledge and skills acquired from using such problem solving software transfer to:
   a. Solving math problems in a math environment?
   b. Using math to help solve problems in non-math areas?

The first piece of problem-solving software examined in this inservice session (*Mind Puzzles* by MECC) is quite simplistic. However, it allows discussion of the above questions, and this discussion can lead into other related questions. For example, suppose that a student develops good skill at solving computer-based maze problems. Does this help improve spacial visualization skills or planning-ahead skills?

Pat McClurg did her doctorate work at the University of Oregon on a similar question. She found that when students used software such as *The Factory* over a period of weeks, their scores on spacial visualization tests increased more than the scores of those in a control group. Billy C. Yates' dissertation, completed at the University of Oregon in summer 1988, replicated some of the work of Pat McClurg and produced similar findings. These studies suggest that for one particular piece of software there is transfer to the types of skills measured by certain types of spacial visualization tests.

In this inservice session (as in all sessions) we encourage participants to work together at the computers. The research on cooperative learning and cooperative problem solving supports the contention that students learn more about problem solving by working together to solve problems. This might be raised as a discussion topic in one of the debriefings.

The December 1986 issue of *The Computing Teacher* includes an article titled "The Teacher's Role in Using the Computer to Teach Thinking Skills." That article is reprinted in section 4.4.6.

Some Specifics on This Session

The session begins with an off-machine problem-solving activity. There are many books full of such activities. A few sample activities have been included in this part of the Notebook. Select one that you feel will be appropriate to the participants in the inservice.

Spend a short time with the activity and then debrief the steps the participants went through in order to solve the problem. Note that cooperation and working together are needed in some and that there are other activities that may be done alone. Raise the question of whether the problem-solving ideas participants used to solve the problems carry over to solving "regular" math problems.

The second activity is done at the computer. Have the software *Mind Puzzles* by MECC already loaded so that participants can begin at once. Tell participants they will have approximately 20 minutes to get through the software. They should do both *Maze of Rodentia* and *Queen Bee of Menta*. *Maze of Rodentia* is very straightforward with explicit directions. It is a maze game and should be easily understood. *Queen Bee of Menta* is more difficult to understand and some participants may require help. However, the game is also very easy.

Mind Puzzles was selected because of its ease of use and as a tool to help raise questions concerning problem solving. The debriefing may take more time than the time spent on the computer. We use this piece of software to raise questions such as:

1. Is it appropriate to use games in teaching?

2. Is this a "good" piece of software? (How does one judge whether a particular piece of problem-solving software is good? If participants suggest a piece of problem-solving software is good, ask them to cite supporting research studies!)

3. Do people (teachers included) always read directions? Is it possible to write directions that all readers will find to be clear?

The third activity is to be done after the break. A number of "computer stations" are loaded with a variety of problem-solving software programs. (Get the software set up during the break. Use volunteers to help and to serve as assistants at the stations.) There should be software for appropriate low ability and high ability students, and participants visit several stations.

Be sure to allow some time for debriefing, even if this means that participants do not visit every station. (Participants may explore software on their own, but it is harder for participants to have group discussions on their own.) Make sure that transfer of learning is emphasized in the closing debriefing.

4.4.2 Script

Theme

Using problem-solving software.

Objectives

1. To have participants think about what is meant by problem solving and uses of computers to create environments that support the development of good problem-solving knowledge and skills.
2. To increase knowledge of the issue of transfer of learning and to focus on how to increase the amount of transfer that occurs as students use problem-solving software.
3. To explore some problem-solving software.

Materials

Software

- *Mind Puzzles*
- *Teasers by Tobbs*
- *The Factory*
- *Gertrude's Puzzles*
- *High Wire Logic*
- *Rocky's Boots*

Handouts

- Colors of a Cube
- Off-Line P.S. Activity with jigsaw pieces
- Description of each piece of software demonstrated.
- Article from *The Computing Teacher*

Pre-Class

Load *Mind Puzzles* into the computers. The data record sheets should be included with participant handouts.

Introduction
5 Minutes

Begin by having participants work on the Colors of a Cube worksheet without giving them directions. Participants may work alone or in groups. Once an individual or group solves the problem, watch to see if they help each other, give the answer away, or just sit quietly. Use your observations in the debriefing.

Discussion
10-15 Minutes

Debrief the above activity. How did the group react to the problem? What are we trying to accomplish when we do problem-solving activities? Was the activity motivating? How do you think students feel when they are faced with these types of problems? Do these types of activities help students to use what they have learned in a math class? Have the participants keep these questions in mind when they go to the next activity.

Activity
20-25 Minutes

Purpose: Have participants work in pairs and use the MECC *Mind Puzzles* problem-solving software program, thinking about the steps they follow. Tell them that they will have approximately 25 minutes to go through both programs. Give no instructions verbally; participants should have the instruction sheet with them from the handouts.

Discussion
15 Minutes

Debrief the activity. How was this different from the worksheet they received at the beginning? What skills were being used? Was the computer useful for this activity? Would this be useful for students in other areas or is it "just a game?" Did they learn anything from this piece of software? Was it fun? Would they use it anywhere in their curriculum or elsewhere? Try to get everyone involved in the discussion. There are always a few people that have definite opinions, but we are trying to facilitate new thinking and want to get everyone consciously thinking.

Break
10 Minutes

Collect logs.

Activity
30 Minutes

Purpose: To allow participants to see other types of problem-solving software and to have some hands-on time. It is desirable to have some participants serve as facilitators at the stations. Have at least four different pieces of software available for teachers to try out. Have participants pick and choose which ones they would like to see, but keep the group from all gathering at one computer.

Discussion
10 Minutes

Debrief the above activity. Tell them that there is a list of problem-solving software in the handouts. They can mark the ones that are available to them (check ahead of time at resource centers, ESD's, etc., so that you can let them know). The list given here is not intended to be comprehensive, and new pieces of this type of software are published quite regularly. Ask participants if any of them have used a piece of problem-solving software that they have found to be particularly appropriate to their teaching situation.

Close the session by briefly reviewing what was discussed. Problem solving and transference should be something teachers are conscious of and work toward directing students to do on their own.

Set the time and place for the next session.

4.4.3 Timeline

Here is a sample two-hour inservice based on the materials in 4.4.2. Have *Mind Puzzles* from MECC loaded into the computers. A large color screen or monitor is needed for this session.

0:00-0:08 The participants will enter and begin work on the The Colors of a Cube activity. They may work alone or in groups. Do not give any specific instructions.

0:08-0:15 Debrief. What do we hope to accomplish by having students do these types of worksheets? Does the learning transfer to other math problem-solving situations, either in math classes or in other subject areas. Emphasize the idea of transfer of learning, as it is a central theme for today's session.

0:15-0:40 Activity 1. Have *Mind Puzzles* loaded and ready to go. Tell participants they will work in pairs and will have 25 minutes to go through both games. They should make a note of any problems, questions, or answers as they work with the software.

0:40-0:50 Debrief. How many people read directions first as opposed to trying to do the work without reading them? How was this activity different from the worksheet activity used at the beginning of the session? What skills were used in solving the problem? What did they learn from doing this activity? Was it fun? Will the learning transfer? What could teachers do to increase the transfer?

0:50-1:00 Break. Collect logs and Game of the Week sheets.

1:00-1:10 Debrief Game of the Week.

1:10-1:20 Demonstration using *Rocky's Boots*. Model how one might use a single computer in the classroom. Involve the whole group.

1:20-1:50 Debrief briefly and explain that for the next activity there will be six different stations available, each with one piece of software, *Rocky's Boots, Getrude's Puzzles, High Wire Logic, Teaser's by Tobbs , The Factory and MECC Math Vol. 1*. They will have 30 minutes to visit two or three different stations.

1:50-2:00 Debrief the activity. Which software seemed most useful for working with students? What could students learn from using pieces of software like these? Will transfer of learning occur, and what can teachers do to increase transfer? Is it okay to play such games and have fun during a math class?

Research says that one gets better at problem solving by being in a problem-solving environment in which one practices problem solving. Is the typical secondary school math classroom a good problem-solving environment in which students can practice solving problems? Research also says that a teacher's attitude toward problem solving and transfer of learning is an important factor.

4.4.4 Handouts

The pages of this section contains handouts needed in Session 4. The facilitator may find it useful to make some of these into overhead projector foils for use during the inservice.

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Problem-Solving Software for Mathematics 5
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Colors of a Cube (A Problem/Puzzle)

A cube has six sides, each a different color.

The red side is opposite the black.

The green side is between the red and black.

The blue side is adjacent to the white.

The brown side is adjacent to the blue.

The red side is face down.

What color is the side that is opposite the brown side?

Now that you have finished, answer the following questions.

1. What grade levels of students might be able to solve this problem, and what do you think students would learn from doing this exercise?

2. What skills are used in solving this problem? Name some places in the math curriculum or in applying math to other disciplines where these skills are useful.

Introduction to *Mind Puzzles* by MECC

Mind Puzzles helps students to develop a variety of problem-solving skills that apply to virtually all curriculum areas. *Mind Puzzles* is process-oriented rather than subject-matter oriented and can be used whenever the objective is to develop thinking skills and processes rather than to acquire knowledge. The programs are designed for individual or small group use by students in grades 6-9. The program emphasizes a discovery approach to problem solving, and it encourages students to use the computer as an exploratory tool.

Mazes of Rodentia presents students with a number of mazes of varying complexity. Students must successfully navigate the mazes in order to win a tournament. There are three different winning categories. To succeed, students must exit a maze with the fewest number of moves.

In *Queen Bee of Menta*, students explore the programs to discover the secret code which involves a 4 x 4 matrix of symbols and their associated screen displays. Screen displays include characteristic borders, movements, formations, and sounds. The exhibition of each type of characteristic is determined by the order in which the symbols are selected.

A Top Ten Scores frame is part of each program. A Teacher Option enables teachers to view or delete the names of the ten top-scoring players in each category. This option is available for both *Mazes of Rodentia* and *Queen Bee of Menta*.

Students can exit the program at any time by pressing *Esc* twice in a row when the program is waiting for input.

Mind Puzzles (Performance Aid)

A. *To get started*:

1. Insert the *Mind Puzzles* disk, close the drive door and turn on the computer. (Or, do a warm boot by inserting the disk and depressing the Open Apple, Control, and Reset keys all at the same time.)

2. Type in 1 and then press the Return key to choose *Mazes of Rodentia.*

3. Type in Y to the next question. Take any notes you may need here:

4. First choose Maze Level 1 (Later choose 2, 3, or 4).
5. Traverse and Record. You will want to develop a systematic record keeping scheme. This is an important idea in solving many types of problems.
6. What happens when a different aid is chosen?

7. How is the highest score obtained?

B. *To advance*:

1. After returning to the menu, choose 2 and press Return for the Queen *Bee of Menta.*

2. Y (Return) to read about the history.
   N (Return) to receive training.

3. Begin as an Apprentice Bee Keeper, Level 1.
   Go through the tutorial.
   N (Return) to the next level of training.

4. Now become trained as an Apprentice Bee Keeper, Level 2. You will need to develop a record keeping scheme.

5. After that training, accept the challenge of 3 (Return).
   Use your record keeping scheme to gather data about these four new symbols and each of their attributes.

C. The *Mind Puzzles* software from MECC is accompanied by a booklet containing some good support materials. Look through the booklet from MECC for a more thorough understanding of this disk. In the booklet you will find sample recording sheets that can be provided to students. Which is better -- providing students with recording sheets, or asking them to develop their own recording sheets?

Problem-Solving Software for Mathematics

Here is a short list of some problem-solving software currently available that is generally acknowledged to be of good quality.

Sunburst Communications. 39 Washington Ave., Pleasantville, NY 14850

• **The Factory**	Spatial relationships, multiple solutions.
• **The Super Factory**	Three dimensional visualization and rotation.
• **Geometric Supposers**	Geometric concepts. There are several major pieces of software in this series.
• **High Wire Logic**	Deductive logic, Boolean operations, critical attributes.
• **The King's Rule**	Inductive reasoning, numerical patterns and relationships.
• **Puzzle Tanks**	Math and logic skills, multiple solutions.
• **Safari Search**	Deductive reasoning, analysis.
• **Teasers by Tobbs**	Problem solving.
• **Semcalc**	Working with a variety of units in word problems.
• **Interpreting Graphs**	Graphs are given and the user must find the situation that has been graphed.

The Learning Company. 4370 Alpine Rd., Portola Valley, CA 94025

• **Gertrude's Puzzles**	Spatial relationships, critical attributes.
• **Moptown Hotel**	Sequences, deductive reasoning.
• **Rocky's Boots**	Logic, spatial relationships.

MECC Software. 3490 Lexington Avenue North, St. Paul, MN 55126

• **Problem-Solving Strategies**	Looks at exhaustive search, trial and error, making lists and tables, and simplifying the problem.
• **Math Vol. 1**	Eight programs to solve math problems for 6th grade on up.
• **Math Vol. 4**	Thirteen programs for Algebra II - Trig students on up.

Conduit. The University of Iowa, Oakdale Campus, Iowa City, IA 52242

• **Graphing Equations (Green Globs)**	Problem solving through graphing.

Rocky's Boots

(Grades 2 - College)

Rocky's Boots is logic-oriented problem-solving software. It is in a game format where the "player" moves from room to room as he or she learns what each piece does and how to connect them. There are six sections, each with varying numbers of rooms, which increase difficulty as you go up. Some of the skills involved include: activating targets, identifying positive and negative values, recognizing and avoiding glitches, building and debugging circuits, classifying, abstracting and inferring, applying Boolean logic to solve problems, and using combinatorial logic. You will need a color monitor to use this piece of software.

When using this software for demonstration, it may be helpful to copy pages 25 and 26 of the manual that accompanies the software for a handout. These pages give a screen picture and a short description of each section.

The package comes with a diskette and a student handbook. There are versions available for Apple, Commodore, IBM, and Tandy computers. *Rocky's Boots* retails for $49.95 and is available from:

The Learning Company
545 Middlefield Rd.
Suite 170
Menlo Park, CA 94025
(800) 852 - 2255

Gertrude's Puzzles

(Grades 1 - 6)

Gertrude's Puzzles is a problem-solving program that builds basic thinking skills. It is an exploratory game in which students solve puzzles. To play the game and solve the puzzles, players must understand and use the attributes of the playing pieces on the screen. They do this by following rules of classification and ordering based on color and shape. As they move through the various rooms, they can control the environment by choosing which puzzle to solve and the level of difficulty. You will need a color monitor to use this piece of software.

When using this piece of software for demonstration, it is helpful to have pages T7-T9 from the documentation ready for handouts. These pages contain screen pictures of the eight rooms as well as a short explanation of what can be done in each room.

Gertrude's Puzzles comes with a diskette and student handbook. There are versions available for Apple, Commodore, and IBM computers. *Gertrude's Puzzles* retails at $44.95 and is available from:

The Learning Company
545 Middlefield Rd.
Suite 170
Menlo Park, CA 94025
(800) 852 - 2255

High Wire Logic

(Grades 5-9)

High Wire Logic is a game based on Boolean logic. There are two options in a game setting. Some of the skills involved in this piece of software include: working with higher order rules, identifying multiple solutions, scanning for clues and hints, making organized lists, and examining assumptions. You will need a color monitor to use this piece of software.

The PRACTICE option introduces and allows students to practice six logic types: and, or, and-or, and-and, or-or, and the exclusive or (xor). The PLAY option shows students two sets of colored shapes; one set is up on a high wire, the other set falls to the net below. The shapes on the wire fit the rule. The shapes in the net do not fit the rule. Students are challenged to write as many rules as they can that fit the shapes on the wire but not the shapes in the net. The more difficult the logic type used, the higher the points awarded for each correct rule.

When using this piece of software for demonstration, it may be helpful to have pages 4-8 from the documentation ready to pass out to participants. These pages have screen pictures and a short explanation of each rule.

High Wire Logic comes with two diskettes and a teaching guide. It is available for the Apple computer and retails for $59.00. It is available from:

Sunburst Communications
Room D 7575
39 Washington Ave.
Pleasantville, NY 10570-9
(800) 431 - 1934

Teasers by Tobbs

(Grades 4-10)

Teasers by Tobbs is a problem-solving program that provides drill and practice for addition and multiplication facts. The game is in the shape of an addition or multiplication grid. The grid presents a series of math problems, each with a missing number. Students decide which number can't be, might be, or must be the correct solution. Students can play solo or in groups and a score is kept. There are six levels, each one advancing in difficulty.

Teasers by Tobbs comes with two programs, a diskette, teaching guide and back-up diskette. There are versions available for Apple, Atari, TRS-80, IBM, and Commodore computers. *Teasers by Tobbs* retails for $59.00 and is available from:

Sunburst Communications
Room D 7575
39 Washington Ave.
Pleasantville, NY 10570-9
(800) 431 - 1934

The Factory

(Grades 4-12)

The Factory is a problem-solving visualization game designed to teach several strategies: working backwards, analyzing a process, determining a sequence, applying creativity, visual reasoning, and rotation. There are three levels. The first level allows students to experiment with three machines. The second level allows a student to make a product and challenge other students to produce that product. At the third level the computer creates a product and the student must produce it.

The Factory comes with three programs, a diskette, teaching guide, and back-up diskette. There are versions for Apple, Atari, Commodore, TRS-80, and IBM computers. There is a network version available. *The Factory* retails for $59.00 and is available from:

Sunburst Communications
Room D 7575
39 Washington Ave.
Pleasantville, NY 10570-9
(800) 431-1934

MECC Math Volume 1

(Grades 3-6)

This software package gives students experience in using basic logic to master elementary math concepts. There are three different games available. Students interpret clues as they try to guess a secret number, track down a "hurkle" hiding on a coordinate grid, or confront a factor-grabbing fiend.

MECC Math Vol. 1 comes with a diskette and a teacher's guide. It is available for the Apple computer. *MECC Math Vol. 1* is available from:

Minnesota Educational Computing Corporation
3490 Lexington Ave. North
St. Paul, MN 55126
(612) 481-3500

Note that many states, provinces and school districts have MECC site license contracts. The license allows multiple copies of software to be made for classroom use.

Your Name ______________________________

Game of the Week

1. Ask your students to give you an example of a real life situation outside of school in which they have had to use the types of math skills and content being taught in the math course they are currently taking. Also, ask them to provide an example of an application of these math skills from another class (not math class) sometime during the current school year.

OR:

2. Write down some examples of what **you** do in the classroom that facilitates transfer of learning. (If you have never asked your students what could be done in class to help increase transfer of learning, you might try doing that and then discussing the results.)

Game of the Week Outcomes

This is not intended as a handout. Rather, it is a brief discussion to give the inservice facilitator some ideas on what outcomes may be expected from the Game of the Week. There were two choices for this week's game.

1. Ask your students to give you an example of a real life situation outside of school in which they have had to use the types of math skills and content being taught in the math course they are currently taking. Also, ask them to provide an example of an application of these math skills from another class (not math class) sometime during the current school year.

To a large extent, students gave responses bases on math skills learned prior to their current course. Typical answers from middle school students (grades 6-8):

- Do +, -, x, / of whole numbers ,decimals, and fractions for:
    - shopping
    - counting items
    - keeping score
    - checkbook balancing
    - saving money
    - differences in dates/time
    - home ec/cooking/calories
    - dividing people into groups
    - bills
    - how many pages left to read
    - locker combinations
    - telling time
    - checking lunch money
    - taxes
    - profit making
    - comparative shopping
    - science—timing/measuring
    - figuring out grades
    - averages/sports/pop. density
    - interest
    - estimating
    - mileage/distance
- teaching
- computer class/games
- playing chess/cribbage/monopoly
- measuring/metal shop/building something
- finding area/scaling/drawing/architecture
- computer circuits on a chip

High school students answered as follows:
- finding discounts
- centering a mirror/carpentry/architecture
- probability questions
- programming graphics on a computer
- analyzing problems for solutions/what method to use
- reading and interpreting tables
- formulas and when to use them
- doing two column and algebraic proofs
- making graphs/scale drawings/maps
- in science/forensics
- planning a trip/distances
- proportions
- changing Fahrenheit to Celsius
- cooking
- paychecks
- surveying
- rate of change
- area, volume, work
- games/sports
- enough money/age/bank accounts

2. Write down some examples of what **you** do in the classroom that facilitates transfer of learning.

- recipe adjustment
- kids compute own percentage for quiz grades
- give practical, real life situation story problems and problem-solving problems
- simulations (e.g., cost of a home with interest held constant)
- have students look for patterns, guess at answers, sketch
- break down a difficult problem into a series of easier problems
- give questions resulting from the answer to the problem to make them think about the problem
- numerical guessing games
- cut and paste/ making models with polygons
- use materials from the real world (newspapers, checks, etc.)
- do scientific experiments that relate to math formulas or concepts
- applications in real life that involve students whenever possible
- assign problems where students must use prior knowledge and the current lesson in order to complete the assignment
- average and sort data

4.4.5 Materials

These sample lesson plans are designed to be used with students at a variety of grade levels. They represent of the types of activities that can be done with students after learning the material in Session 4.

Inservice facilitators will want to use some of these materials during the session. If the session is more than two hours in length, it is appropriate to have participants work through a number of these student activities.

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Off-Line Problem Solving Activity
(Jigsaw Puzzle)

Description:

Topic: Problem solving—Hypothesis Posing
Grade level: 2-12
Time: 3-5 minutes
Grouping: Whole group
Materials: Letters that spell a word with each letter cut into puzzle pieces.
Objectives: 1. No single student can solve the problem from the start.
2. All students participate.
3. Students develop group building skills of communication, cooperation, and trust.

Before you start:

Select a word such as COMPUTER, or PROBLEM. Cut out the letters of the word selected in large block format, with individual letters being perhaps six inches high, and the "lines" making up the letters being about an inch wide. Then cut each letter into several pieces using a jigsaw cut. Now you have a jigsaw puzzle which assembles into a collection of letters, and the letters can be formed into the original word.

Lesson:

1. As students come into the classroom, hand each student one or two pieces, so that all pieces of the puzzle get distributed. Do NOT explain the problem to them.

2. Make observations about what students are doing with pieces and state those out loud. "Jane is holding up her piece." "Jack is turning his around and flipping his piece."

3. Encourage anyone who is trying to combine two pieces. Allow students to move to combine pieces or check a fit.

4. Once a couple of students begin to recognize that letters can be formed, encourage the rest of the students to engage in forming letters.

5. At this point students may decide that the letters can be combined to spell a word. Typically, someone takes over leadership and arranges the letters. If not, a question to ask might be "What can you do with these letters now?" The teacher can then write the letters on the board for all in the class to see.

6. Debrief the activity. Have students verbalize the steps in the problem-solving process. Reinforce the concept of problem posing. There were two problems: what the pieces were for and what the letters combined to make. Reinforce group cooperation, communication, and trust.

Follow-up: (Other problem-solving activities)

1. Ask students to arrange themselves alphabetically without speaking.

2. Students are blindfolded and then asked to arrange themselves by height without speaking.

3. Form a circle of four students holding hands. Bring all hands to the center, let go of those hands, and take hands from elsewhere in the circle (no two people holding only each other's hands). Now untie the knot to form a circle without letting go of hands. Some students may end up facing the outside of the circle. Now form a group of five or more students and repeat the activity. Is it possible to untie a circle of six students?

4. Any problem which meets these conditions:

   a. No one person can completely solve the problem alone.
   b. Communication is required in some form for the problem to be solved.
   c. Movement of materials or students.
   d. Takes less than five minutes.

MECC Math Vol. 4

Description:

Topic: Problem Solving
Grade Level: 11-College
Time: Varies
Grouping: Demonstration or Individual Use
Objectives: Using the computer to solve complex equations.

Materials:

Software: MECC Math Vol. 4
Equipment: Apple and monitor, data disk, Printer (optional)

Before you start:

Select problems that would be very time consuming to solve manually.

Lesson: (Sequence of instructional activities)

- Students then use the proper program to solve the problem.
- Problems that encourage changing the parameters or function values should be posed.
- Use real world problems and have students find methods for solving these problems.
- Have them compare the efficiency of the various methods.

Follow-up:

- Have students find real world problems that would be very difficult to solve without the help of these programs.
- What other areas of mathematics should use the computer as an aid to solve the problem?
- Where in the real world is the computer used to solve problems?

Comments:

Each of these programs has a very specific format. It will be necessary to spend some time to understand the proper inputs.

The Factory

Description:

Topic: Thinking Backwards
Grade Level: 3-12
Time: One or more 15 min sessions
Grouping: Whole class or groups of 2 or 3
Objectives:
1. Thinking Backwards Strategy
2. Exercise Spatial Relations
3. Sequencing Steps Strategy

Materials:

Software: *The Factory* by Sunburst
Equipment: One or more computers
Other materials: concrete aids
or problems

Before you start:

1. Do a problem in class that is best done by thinking backwards. Here are two examples:
   a. Seymour left a plate of brownies to be equally divided among Jim, Judi, and Larry. Jim took his share to his room. Judi did not know Jim had any so she took what she thought was her share. Larry came in and not knowing that Jim and Judi had taken cookies, took his share. This left 8 cookies. (Answer not given. This could be done with real brownies.)

   b. Begin with a graph and figure out the equation that the graph represents.

2. Do a problem that requires some spatial manipulating. Examples may be found in many different puzzle books.

3. With a large screen monitor or projection system, and using *The Factory*, under Make a Product, have the whole class determine how to make one easy product. This allows you to work on vocabulary, discuss sequencing, and verbalize strategies.

4. This is a continuation of 3. Have the students close their eyes. Describe three machines in a particular order. Students are to visualize the product that the machines would produce and then draw their predictions on paper. Then use *The Factory* to check their predictions.

Lesson: (Sequence of instructional activities)

1. Working in groups of two or three students, go to the machine and design an easy product.

2. After students have all designed an easy product, have students work in groups of two or three to create a more difficult product.

3. Students design a factory on paper. Predict their product. Test out the factory design and check how close they were to the prediction.

4. Students challenge others to design a factory that produces their product.

5. Students come up with other examples in everyday life that require the Thinking Backwards strategy.

Follow-up:

Follow-up:

1. Select problems that would be very difficult to solve without lots of calculation or time, and have students identify when Thinking Backwards is the appropriate strategy.
2. Do some imagery exercises with various problems in the future. Just have students close their eyes and form the appropriate images for a certain setting and then begin the lesson.

Comments:

Visualizations are helpful in developing concepts. They provide a deeper understanding of mathematics. The ability to visualize and manipulate shapes can be developed through practice.

Research evidence suggests that students get better at spatial visualization through practice. Also, spatial visualization skills are useful in attacking a wide range of math problems. There are innumerable activities that you can ask your students to do that will provide practice. For example, ask your students to work from memory and:

- Draw a floor plan of where they live.
- Draw a map of a route from where they live to the school.
- Draw a floor plan of the school.
- Sketch a picture of a friend and give details of how the friend was dressed yesterday.

Problem Solving Strategies: Diagonals

Description:

Topic: Problem Solving Strategies
Grade Level: 5-9
Time:
Grouping: Demonstration; divide the students into groups of four.
Objectives: Learn three problem-solving strategies:
1. Trial and Error
2. Simplifying
3. Exhaustive Listing

Materials:

Software: MECC Problem Solving: Strategies: Diagonals
Equipment: Apple computer, monitor
Other materials: Dodecagons drawn on handouts for student

Before you start:

This can be part of a problem solving unit or done as an individual lesson. You may review basic geometric parts (e.g., sides, vertices, and diagonals) before the lesson or let the program do it.

Lesson: (Sequence of instructional activities)

Demonstration: Use the tutorial aspects of the program for a demonstration. Students work on the problem individually as the program asks questions. The sequence of steps is:

1. Have you used this program before? Answer No. Then do the tutorial on dodecagons.

2. Program will go through the following strategies:

   a. *Trial and Error* Have the class guess the number of diagonals.
   b. *Make an Exhaustive Listing*—Students work at their desks and try to list all the diagonals. Do they get them all?, leave some out?
   c. *Simplifying the Problem*—Students will make a table and find the number of diagonals in a triangle, square, pentagon, hexagon, etc., trying to find a pattern.

Student Groups: Divide the class into groups of three or four students.

1. Teacher introduces the problem and reviews the vocabulary (dodecagon, sides,vertices, diagonals).

2. From the main menu of the program *Diagonals* choose the strategies you wish to explore.

   a. *Trial and Error*—Have each group guess the number of diagonals. Ask if they used any strategy in their guessing.
   b. *Exhaustive Search*—Divide the groups so that there is a recordkeeper to keep track of all of the diagonals.
   c. *Simplify the Problem*—A recordkeeper is needed to make a table. Everyone in the group attempts to find the formula for the pattern.

3. Ask the class to decide when each strategy is most appropriate.

Follow-up:

Have the class extend their answers to find the number of diagonals in 15 or 20-sided figures. Use these strategies with other kinds of problems.

Comments:

This program could be run by groups of students as a tutorial. This well-directed program does not need teacher supervision.

Teasers by Tobbs

Description:

Topic: Problem Solving
Grade Level: 3-9
Time: 5-7 min/level
Grouping: 2 per computer
Objectives: Use problem-solving strategies such as:

1. Guess and Check
2. Inductive Reasoning
3. Thinking Backwards

Materials:

Software: *Teasers by Tobbs*
Equipment: Apple Computer
Other materials: scratch paper

Before you start:

Students should know their addition facts before using the addition portions and their multiplication facts before using the multiplication portions.

Teasers by Tobbs is sequenced to take the user from beginning drill through deductive reasoning. The reinforcing drill allows students reinforcement of their arithmetic facts and time to adjust to the format of the program and the computer. The later levels of difficulty present problems in a "backwards" presentation and lead into deductive activities.

Lesson: (Sequence of instructional activities)

1. Students should proceed through the different levels at their own pace.
2. The teacher can use the program for demonstration, reinforcement, and strategy clarification at different points during the year.
3. Instead of asking for the answer, ask for the two numbers that form the answer where Tobbs is sitting.
4. This can be used in an introductory Algebra course, as the higher levels introduce solving equations and the concept of variables.

Follow-up:

Have students design arithmetic grids similar to those in the program to challenge others in the class or other classes.

Comments:

Stress the analysis of the strategies used to solve the problems. Get students to verbalize the strategies and understand that multiple correct solutions exist to any given problem.

Tic Tac Show Lesson Plan

Description:

Topic: History, Science etc.
Grade Level: 4-5
Time: 20 min + 20 min + 20 min
Grouping: 2 or 3 students working together
Objectives: Students design a quiz, take the quiz, and revise the quiz

Materials:

Software: *Tic Tac Show* by Advanced
Equipment: One or more computers
Other materials: Student questions on paper

Before you start:

- This can be one group or many different groups.
- Students will design a quiz containing questions relative to a specific topic and supply all the right answers to the questions. They must keep in mind that the questions will be given to the whole class.
- Select the topic or source of content to be quizzed.
- Students should have played *Tic Tac Show*.

Lesson: (Sequence of instructional activities)

1. Students write up 10 questions.
2. They write all the possible correct answers to the 10 questions.
3. They enter the questions in the editor for *Tic Tac Show* and then save the file on disk.
4. They play the game and check their quiz with correct and incorrect answers, taking notes on any possible changes.
5. Students then go back to the editor and revise their questions and answers.
6. The teacher now plays *Tic Tac Show* with the whole class as a review before a quiz.

Follow-up:

1. Quiz someone else's room with the material.
2. Have students from another room design a quiz for your room.
3. Have the students present the quiz at a PTA or PTO meeting.

Comments:

The major purpose of this lesson is to have students analyze their wording and become comfortable with revision. Some additional products include the realization that often questions have more than one acceptable right answer (e.g., What is 3+4? Some possible answers include: Seven, 7, VII, 2 + 5, 8 - 1, a lucky number, and 4+3) , analysis of what content is important in a section, and student cooperation.

4.4.6 Readings

Note: The December 1988 issue of *The Computing Teacher*, which is published by ICCE, is a theme issue focusing on Thinking Skills and Problem Solving. Some of the articles from this issue of *The Computing Teacher* might make suitable handouts for a workshop.

The book *Computers and Problem Solving: A Workshop for Educators*, by David Moursund, (published by ICCE) contains a large number of activities that can be used in an inservice workshop.

The Teacher's Role in Using the Computer to Teach Thinking Skills

by
Robert M. van Deusen and Jean Donham

[From the December/January 1986-87 issue of The Computing Teacher. *Reprinted with permission.]*

We teachers have complained about the quality of instructional software for some time. But our complaint is becoming less valid as software developers have begun to identify a curricular niche for the computer: thinking skills. Attempts to teach thinking skills in the context of social studies, science, or literature are sometimes unsuccessful because in the struggle between teaching *content* and teaching *process*, content often wins. What is needed is a manageable environment in which the focus can be placed on process—the thinking skills.

How Do We Create Such an Environment With a Computer?

As educators, many of us have tended to assume that for students to learn with a computer, they must be seated at it, hands on. There are indeed situations in which that is appropriate. However, if the teacher is to play an active role in focusing on skills and strategies, then the *teacher* must be interacting with students and the computer. To teach thinking skills, such teacher direction is essential. A 25-inch monitor for the students, one computer, and a small monitor for the teacher is an appropriate arrangement. The teacher can then run the program and direct the instruction, focusing on the targeted thinking skills, labeling those skills, and increasing the probability of transfer.

Appropriate software can help the teacher create a manageable environment to focus on thinking. The following criteria can assist in choosing this software:

- Does the software focus on significant thinking skills as its objective?
- Are there multiple levels of difficulty so that the teacher can adjust to students' needs?
- Are there multiple solutions that vary in sophistication?
- Does the software have multiple problems so that it can be used repeatedly?
- Is the software designed for a cooperative, non-competitive environment?

Most software designed to teach thinking skills does so within a specific situation that can be effectively modeled with the computer. Figure 1 lists examples of exemplary software with which to teach thinking skills. Avoid the assumption that software teaches. It is the teacher who teaches; the software is only the medium.

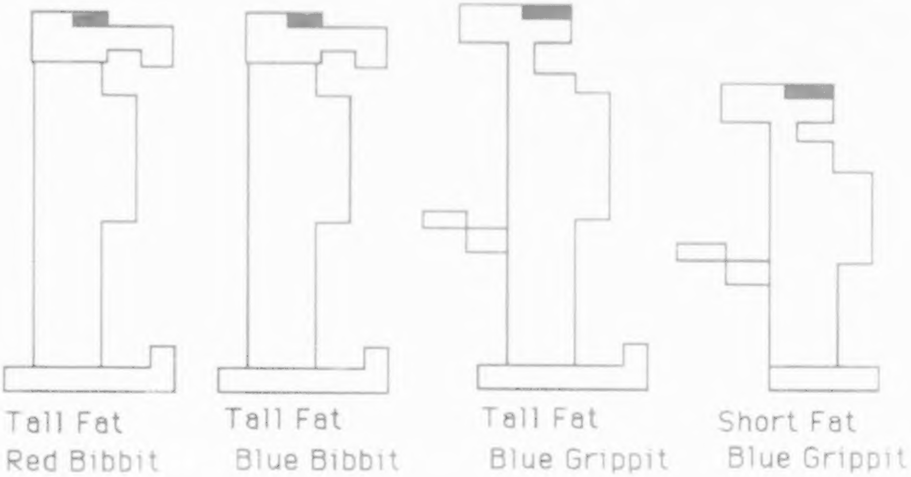
What Does the Teacher Need to Do?

As with any instructional material, the teacher must personally learn how to use the software first. Learning the software is always composed of two parts: learning the mechanics of the levels, choices, exit mechanisms, and help systems which allow one to move between the various components of the program; and understanding the learning objectives of the program: what is it designed to teach? How can the teacher facilitate that learning? And what kind of questions should the teacher ask which will cause students to actively develop the structures and insights this program is designed to encourage? This second component—the teaching component—is often totally neglected. This often occurs when teachers assume that software teaches. Teachers teach, and in order to effectively do so, they need to know where they are going or they're liable to end up somewhere else.

"Where teachers are going" is in search of thinking processes, not in search of right answers. Consider, for example, *Safari Search* from Sunburst Communications. *Safari Search* was designed to teach deductive logic, analysis, and hypothesis formation and testing. A 5 x 5 grid is presented, behind which hide one or two animals. Each cell of the grid will display, upon being chosen, relevant information about the direction of or proximity to the hidden animal(s). It is, of course, the *process* of determining the location of the animals, the language used to explicate that process, and the thinking behind that language which the teacher wants students to experience.

If the teacher has worked through the program as a *learner* and then stepped back to analyze the process used, it is often clear that a model or manipulative would aid the student while using the software. Physical models or paper/pencil two-dimensional semi-concrete models can aid in the development of the concept or strategies being learned.

For example, when using The Learning Company's *Moptown Parade* at Level 6, it is very desirable to use physical manipulatives of the 16 possible Moppets (two heights, two weights, two colors, and two kinds). In Level 6 students line up the Moppets, changing one, two, three, or four attributes between each of the five Moppets in the parade. Learners benefit significantly by actually moving the manipulatives and checking to see if each differs by the specified number of attributes. While some students will limit themselves to a "guess and check" strategy, others will progress to analysis, generalization, elaboration and synthesis through the use of manipulatives. This focus on the *process* of learning through actively *manipulating the environment* and *creating* their own knowledge allows students to connect the artificially divided compartments of learning into a fabric of related elements.



While working through the learning objectives, the teacher may divide the students into cooperative groups to gather and organize data, form and test hypotheses, make generalizations, elaborate, find multiple solutions, or even write an algorithm for the general solution to the class of problem. Cooperative groups allow students to develop their own theories on the problem and its possible solutions. In addition, students who are frustrated at a given stage in the problem-solving process have the opportunity to retrace and clarify the process with peers. Cooperative groups also limit the impact of those students who might divulge the essence of the solution before others have had time to process.

Program	Targeted skills
The Factory (Sunburst Communications)	Spatial relationships, problem solving, multiple solutions
The Incredible Laboratory (Sunburst Communications)	Hypothesis testing and formation, organization of data
Safari Search (Sunburst Communications)	Deductive reasoning, analysis
The King's Rule (Sunburst Communications)	Inductive reasoning, numerical patterns and relationships
Moptown Parade (The Learning Company)	Sequences, problem solving, deduction, critical attributes
Teasers by Tobbs (Sunburst Communications)	Problem solving
Gertrude's Secrets (The Learning Company)	Spatial relationships, critical attributes
High Wire Logic (Sunburst Communications)	Deductive logic, Boolean operations, critical attributes
Word-a-Mation (Sunburst Communications)	Word relationships, pre-analogy
Puzzle Tanks (Sunburst Communications)	Problem solving multiple solutions

Figure 1.
Software for Teaching Thinking Skills

The teacher's role in questioning throughout the process is critical. Thinking out loud is an important aspect of teaching thinking skills. Teachers can demonstrate effective strategies for problem solving by creating an environment in which all thinking is thinking aloud. Often a three-step questioning approach is useful. *What* do you think? establishes the students' positions. Whether right or wrong, the follow-up needs to be asked: Why do you think it? This elicits the rationale behind the students' thinking. Follow-up questions which explore exceptions, special cases, and apparent contradictions will cause students to push their own thinking as far as it can go. The third question, How did you figure it out? asks students to relate the steps or processes used in arriving at the stated position.

The teacher must pursue all three steps. Whether the initial answer to the "What do you think?" question is *right* or *wrong* is irrelevant. The answers to the final two questions are much more revealing than the answer to the first question.

The teacher's role in the model shifts from evaluator to facilitator. A metaphor may help to clarify the distinction. The leader of a mountain-climbing expedition has choices: She or he can climb independently to the top and extol the beauty and virtues of the mountain, and then try to pull everyone else up the mountain; or can work with the climbers every step of the way as a fellow mountain climber, albeit one with more experience and knowledge. It is this latter technique that the computer allows, with teacher and students as allies. What do you think *we* ought to try first? Why did you choose that? What will happen if *we* do this? How did you figure that out? What else could *we* do? Do you agree or disagree with that? Why? How else could *we* solve this? Is one way better than the others? How do you know? When students make suggestions, the teacher must resist being the evaluator—the answer-giver. Rather, the teacher should ask questions to explore the thinking and then test the student's suggestion on the computer. The computer will provide the feedback. Why do you suppose that didn't work? What could *we* do differently next time? Why do you think that will make a difference? What's different about your two responses? What's the same? Which difference is critical? How do you know? These questions help students to monitor their own thinking.

When the teacher assumes the role of guide rather than director, students experience attitudinal change—they are more willing to take risks, to try different approaches. Risk-taking is encouraged when the teacher's responses are characterized as accepting, building upon, integrating, and extending student ideas. If risk-taking is encouraged in the classroom, the *process* of learning will in fact produce learning.

How Does the Teacher Encourage the Transfer of Learning?

The computer can help create a manageable environment for focusing on skills. But at some point those skills need to be applied in a new environment if they are indeed to be learned. Transfer of learning from one situation to another is not automatic; it requires teacher direction. A critical step in effective teaching is to apply the skills or strategies taught in the computer-assisted lesson to other situations. For example, suppose the teacher has been using Sunburst's *The Incredible Laboratory* to focus on hypothesis formation and testing, and those same strategies apply in science units, McGraw Hill's Elementary Science Study (ESS) "Mystery Powders," for example. It is the teacher's role to make the connection, to say, "Remember when we. . . "

The computer has been derided by many as a passing fad, as a resurrection of teaching machines, as a toy, and as replacement for flash cards and workbooks. But the surge in development of software for teaching thinking skills suggests we may now have a way to teach skills we had not been able to teach effectively before computers.

Barry Beyer from George Mason University has related research on how we learn skills to the teaching of thinking skills specifically. Several of his findings are relevant to the teacher role discussed here. Beyer's research suggests that any skill is best learned when learners:

1. **Are consciously aware of what they are doing and how they do it**. The teacher-directed learning and questioning strategies recommended here help create that consciousness for learners.

2. **Are not distracted by competing input**. The microcosm created by the software eliminates distraction and focuses on specific skills and strategies.

3. **See the skill modeled**. The teacher, taking a collaborative position, can model the skill(s) relevant to the specific software.

4. **Verbalize their processes as they engage in the skill**. The How do you know? and Why do you think that? kinds of questions encourage this.

5. **Receive opportunities to practice the skill in contexts other than that in which the skill was introduced.** The teacher's efforts to facilitate transfer—by relating skills learned to content area activities—is critical for transfer of learning to occur.

Teaching thinking skills must be deliberate; we cannot expect such learning to occur by seating students at computers to independently experience even the best software. The teacher's role is the critical factor for capitalizing on the instructional potential of microcomputers. *Remember:* Teachers teach.

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4.5
MATH SESSION 5: DATABASES

4.5.1 Narrative Overview

Computers are changing the basic nature of information storage and retrieval. Two major categories of computerized information storage and retrieval systems have been developed. The first is called a *bibliographic* information retrieval system. It is designed for the storage and retrieval of articles and books, or references to articles and books. Many educators are familiar with the Educational Resources Information Center (ERIC) system. It contains hundreds of thousands of references to educational materials. Material in the ERIC system is indexed under key word descriptors. Users of the system can retrieve both detailed citation information and abstracts of the articles in the system. Some bibliographic systems contain the entire articles and books that people want to access. Decreasing costs of computer storage are making such systems more common.

There are now hundreds of commercially available bibliographic retrieval systems. Generally they are accessed via telecommunications systems and are moderately expensive to use. Use of such systems is common at the graduate student and researcher level. In the past couple of years, use has begun to occur at the secondary school level. The CD-ROM laser disc eventually will become common in schools and people's homes. Thus, it is appropriate for all students to learn to use bibliographic retrieval systems.

The second major category of computerized information retrieval system is usually called a *database*. A database typically is a collection of factual information organized into records and fields. An example is provided by a teacher's gradebook. There is one record for each student. Each record is divided into a number of fields, such as score on first homework assignment, score on first quiz, score on second homework assignment, etc. An airline reservation system is a database with information about each flight, the seats available, which seats have been sold, etc.

Database systems are both easy to use and easy to learn how to use. Even at the grade school level students can learn to use such systems and quite a bit of instructional material has been developed. By the upper elementary grades students can learn to create their own databases, enter them into a microcomputer system, and use them to solve problems. A number of school districts have begun to integrate such computer use into their elementary or middle school curriculum.

The topic of database is **not** central to the current mathematics education curriculum. We devote one full session to the topic for two reasons. First, databases are a very important aspect of the computer field and of computer applications to education. Thus, we introduce the topic as part of general computer literacy for educators.

Second, databases are applicable across the curriculum as an aid to solving a wide variety of problems. A database is used to store, organize, and retrieve information. A number of interesting mathematical problems have come out of addressing issues of storage, organization, and retrieval of information. The topic of sorting algorithms provides a good example. The mathematics underlying sorting is both fun and challenging.

In this session we use the *AppleWorks* database program. One of the main goals of this session is to introduce participants to a database. Just like with spreadsheets, many of the participants will not have encountered computerized databases before. A secondary goal is to help participants learn about an "integrated" package—*AppleWorks* is an integrated software package that allows data to be moved easily among its various applications.

As computer literate educators, the participants should know about databases and some of their uses. Calling up certain data, ordering data, and searching for data are just some of the things a database can do. (*Note*: A calculator can be considered as a storage and retrieval device. A calculator with trigonometric and other functions is a substitute for bulky and hard to use math tables.)

Some questions concerning databases are: Will I be able to make use of a database in the mathematics curriculum? Will it make teaching a particular topic any easier/harder if I use one? Will it make the topic any clearer to students? Can I use it for personal use in terms of grading, keeping records, or any other teacher activities? How can I integrate databases with what I'm teaching?

There are no easy answers to those questions. But a good starting point is to think about the fact that the field of mathematics makes progress through building on the previous work of others. Some of the mathematics we have students learn in school was developed more than 2000 years ago. But building on the previous work of others suggests information retrieval. "Instead of reinventing the wheel, I'll do some library research on how it was previously done."

To what extent do we teach students to look up math materials and ideas in a library? How does the math you teach help students learn to make use of the mathematical progress that has occurred over the past 2000 years? What do students need to carry in their heads, and what do they need to learn how to look up in a book?

4.5.2 Script

This script contains enough material for substantially more than a two-hour inservice. Thus, the facilitator will need to select a subset of it to present in the time available. (Most facilitators will also incorporate a number of their own ideas and materials.) An example timeline for a two-hour session is given in the next section. It represents what was actually done by the NSF facilitators in one particular two-hour session.

Theme

Organizing and retrieving data using a database

Objectives

1. Introduce the structure and format of a database
2. Explore databases in an instructional format
3. Build a database from "raw" data

Materials

Software	***Handouts***
AppleWorks	(LP) Building a Data Table
Apple Presents *AppleWorks*	(PA) AW Database Introduction
Mind Puzzles from MECC	(PA) Intro to AW Database 2
Files: Organic Pies (AW)	(PA) Intro to AW Database 3
Software 86 (AW)	

Note that data for these two files is included in the Section 5.2.4 Handouts for the inservice Session 5. You will need to create the two *AppleWorks* database files and enter the data into them.

Scissors, masking tape
Butcher paper for making a data table
Construction paper and marking pens

Refreshments

Assumptions

It is assumed that participants know the basics of how to load *AppleWorks* and obtain a file from disk. Hand out the Performance Aids and get participants to follow them in exploring the files aspects of AppleWorks. If some students have used *AppleWorks* quite a bit more than others, pair up experienced with inexperienced users.

Pre-Class

Hand out a copy of *Mind Puzzles* for each computer.

Activity
Build a database
(15-20 Minutes)

Purpose: Participants will create a simple database by recording data in free form, then transfer it into a table. The database to be constructed will consist of restaurants and their characteristics. That is, each record will consist of the name of a restaurant and its characteristics. Participants will use discovery techniques to build a suitable organization for the file and what fields each record might contain.

- Use masking tape to put a very large piece of butcher paper on the wall in the front of the room.
- Distribute full (or half) sheets of construction paper and marking pens to pairs of participants.
- Have each pair decide on a favorite restaurant and brainstorm a number of the important characteristics of the restaurant.

Scissors
Masking tape

- Begin building the table by asking participants to cut out the name of their restaurants and taping them along the left side of the butcher paper display.
- Continue building the database by having participants decide on labels for some of the important characteristic of their restaurants, and putting them along the top of the butcher paper display.

Debrief

Review the process of transforming unstructured data into ordered data. Speculate on what hypotheses might be formed and investigated using this data. A very key idea in designing a database is to determine what problems are to be solved, what questions are to be answered, by use of the database.

Activity
Queen Bee of Menta
15-20 Minutes

Instructions on Handout or Overhead:

- Load *Queen Bee of Menta*
- Follow instructions
- Play the simplest challenge in *Queen Bee of Menta*. Note that this same piece of software was used in the session on Problem Solving. Here the focus is on gathering, recording, and organizing information as an aid to problem solving. A database is merely a collection of data. A major theme in mathematics is gathering data, determining a pattern in the data, and using knowledge of the underlying pattern to solve a category of problems.

Debrief

As they use *Queen Bee of Menta*, reinforce the importance of following instructions in the tutorial. Once everyone has begun to organize the data in a table, pull everyone's attention from the computer to a group discussion. Have them explain what has occurred and how they feel. Statements elicited could include: need to organize information, make a table, too much information to keep in one's head. Then turn the focus from the software to the purpose of this session. Participants can check out *Queen Bee of Menta* and take it back to their school to continue the challenge.

Demonstration
5 Minutes

Use a large screen display to demonstrate looking at the records in a computer database and selecting records that have certain specified characteristics. The file used can be one that participants will use later in the session or another one of your choice.

Discussion
5 Minutes

Debrief the activity. What was the computer useful for? What other data might be added to database file to make it more useful? What are some questions that seem related to the database but that cannot be answered using the database?

Break for Refreshments

Collect Logs

Activity
30-40 Minutes

Participants load up *Apple Presents* AppleWorks and work through the tutorial. Then continue by working with the file **Organic Pies**.

Debrief

During or after the activity, ask the same types of questions mentioned earlier. What types of improvements could be made to this database file? Some participants may be writing their guesses and computer responses on paper. How could this be used in problem solving? Can it change or present new opportunities for some of the things we teach in mathematics?

Note also that you may want to spend time debriefing the Apple Presents *AppleWorks* tutorial. What are the good and bad features of these computer-assisted instruction materials?

Activity

Participants load the file **Software 86** and answer questions by making appropriate use of this database. (*Editor's Note*: In a two hour inservice session, there won't be time to work in depth with two different databases. The facilitator will need to decide which of the available databases the participants should explore.)

Closure

Depending on time, discuss where and how to use databases. In what sense are the database ideas presented and explored during this inservice session appropriate materials to include in a secondary school mathematics course?

Handout and discuss the Game of the Week for next week.

4.5.3 Timeline

This sample timeline for a two-hour inservice is based on the materials in 4.5.2. Have Apple Presents *AppleWorks*, *AppleWorks*, and the **AW Sample Files** disks available. This particular timeline uses the **Organic Pies** file from the **AW Sample Files** disk.

0:00-0:05	The participants are organized into pairs and given the favorite restaurant activity orally as they arrive.
0:05-0:15	Use the butcher paper and facilitate participants in developing a restaurant database. During this process, discuss ideas about creation of a database and what types of problems might be solved using the restaurant database.
0:15-0:20	Finish debriefing the initial activity; then give a very brief lecture on databases and their roles in problem solving.
0:20-0:35	Participants work with the *Queen Bee of Menta* problem solving software, with major emphasis being placed on designing appropriate forms for recording data. The idea is that one records data (that is, creates a design for a database and enters data into the database) to help solve a specified category of problems.
0:35-0:40	Debrief the activity by having participants share some of the different data recording formats that they developed. Emphasize that there can be many different databases designed as an aid to solving a specified category of problems or answering a specified category of questions. Two features of a well designed database are that it can be relatively easily used to address related but unanticipated questions, and that it can be extended (expanded) to include related data that may be needed to answer additional questions somewhat related to the original type of questions the database was designed to help answer.
0:40-0:50	Give a whole class demonstration of using a database to answer a variety of questions or solve a variety of problems. (Make use of *AppleWorks* and the **Organic Pies** file.)
0:50-1:00	Debrief Game of the Week; let participants volunteer information from themselves and their students.
1:00-1:10	Break. Collect logs and Game of the Week.
1:10-1:40	Have participants use Apple Presents *AppleWorks* and then go into using the **Organic Pies** file with *AppleWorks* to answer some of the questions about organic pies.
1:40-1:50	Debrief. Was it easy to use? What are some possible educational uses of databases? Explain the Game of the Week that is to be done during the coming week.

Get several volunteers to agree to take home copies of the geometry-oriented software (and its documentation) that will be demonstrated in workstations next session. Their duty is to work with the software enough so that they can load and set up the software, do a demonstration run of it, and help answer questions.

1:50-2:00 The project evaluator will pass out surveys and give instructions. Participants may leave as they finish filling out the evaluation instruments. (Editor's Note: The NSF project staff included an evaluator. A formal formative evaluation of the mathematics sessions was done at the end of the fifth session. Participants were asked to provide quite a bit of information on their opinions about the inservice sessions up to this point.)

4.5.4 Handouts

These handouts are needed by participants during Session 5. The facilitator may find it useful to make some of these into overhead projector foils for use during the inservice.

Participants making use of the Handouts in this section will need access to two *AppleWorks* database files. We have called one of them **Organic Pies** and the other **Software 86**. A listing for each of the files is provided in this section. You (the facilitator of the workshop) will need to enter the files into *AppleWorks* in an appropriate manner to fit the detailed Performance Aids given in this section. Put them on a disk titled **AW Sample Files**.

Index to Handouts **Page**

(PA) *AppleWorks* Database Introduction 2
(PA) Introduction to *AppleWorks* Database 2 3
AppleWorks File Organic Pies 5
(PA) Introduction to *AppleWorks* Database 3 6
Software 86 *AppleWorks* File 8
(PA) Cutting and Pasting Files 10
Game of the Week 11
Game of the Week Outcomes 12

AppleWorks Database Introduction

Part 1:

The software that you are about to use is an example of Tutorial Mode computer-assisted instruction. As you use it, think both about what you are learning and also about the learning experience. Is this a good way to learn about *AppleWorks*? How does it compare to the way *AppleWorks* and its spreadsheet were introduced to you during the Session 3: Spreadsheets part of this sequence of inservice sessions?

Most likely you will want to go through this tutorial with pencil and paper readily available. Make notes on "facts" that seem worth while remembering, but which are not apt to stick in your mind from a single brief computer tutorial presentation. Be aware that the notes you are taking are a type of database.

1. Get an **Apple Presents AppleWorks** disk and load it into the computer with **side 1** facing up.
2. A logo will appear on the screen and then be replaced by a menu. **Introduction** is highlighted on the screen. Press **Return.**
3. A box will appear on the screen. Every time you are done reading, just press the **Return** key to go on.
4. Go through the **Introduction** and press **Return** to go on to the **Overview.** When finished, go on to **Gateway.** Once you are **finished** with **Gateway**, press the **Open-Apple** and **Escape** keys simultaneously.

Pause here. Let your inservice facilitator know that you have reached this point. Then continue.

Part 2:

1. The **menu** should be on your screen with **Introduction** highlighted. Type in the **number 4.** The **Database** should now be highlighted. Press **Return**.
2. A new menu should be on the screen with **Getting Started with the Database** highlighted. Press **Return.**
3. A box will appear on the screen again. Each time you are done reading, press the **Return** key Go through the section on **Getting Started.** When you are finished, press **Return** and go through the section on **Arranging, Moving, and Updating.**
4. When finished with that section, press the **Open-Apple** and **Escape** keys at the same time twice.
5. The original **menu** should now be on your screen. Type in the **number 5** and press **Return.** Remove the disk and put it in its sleeve.
6. Now you will work with *AppleWorks* and a file. Go to the handout **Introduction to AppleWorks Database 2.**

Introduction to *AppleWorks* Database 2

1. Get the *AppleWorks* and **AW Sample Files** disks. Insert **side 1** of the *AppleWorks* disk into **drive 1** and put the **AW Sample Files** disk into **drive 2**. Close the disk drive doors.
2. Follow the directions on the screen. (If there are none, press the **Open-Apple, Control, and Reset keys** at the **same** time).
3. The **AppleWorks** logo should appear on the screen with a **blinking** cursor.
4. Take the disk out of disk drive 1, turn it over and insert it again into drive 1. Close the disk drive door and press **Return.**
5. Type in today's date and press **Return**.
6. The **main menu** should be on the screen with the **Add files** line high-lighted. Press **Return.**
7. A **second menu** called **Add Files** will appear on the screen. The first line should be highlighted and say: **The current disk: Drive 2.** If it does, press **Return.** If not, use the down arrow key to highlight #2 and then press **Return.**
8. A **third menu** will appear with the file **Organic Pies** highlighted. Press **Return.**
9. The file **Organic Pies** will appear on the screen.

Please answer the following questions:

1. Use the **down arrow** key until you reach the bottom of the file. What is the name of the last pie on the list?
2. Arrange the list in order from largest to smallest for total units sold. What were the top three selling pies?
3. Now list them from largest to smallest for total sales. Are the top three pies the same?
4. Which pie(s) would you recommend (if any) that Organic Pies quit making? Why?
5. Arrange the pies in chronological order. Which pie has been made for the longest time? The shortest time?
6. Delete any pie that has not had a total sales of over $1000. How many pies are left?

7. Arrange the pies in order from smallest to largest for total sales. Using the **zoom** function, find out the total profit of the pie at the top of the list.

8. Coconut Custard is my favorite pie. Zoom in and find out how much profit each pie makes. This is the last question for this file!

9. Press the **Escape key** to get to the **main menu**. Since you no longer need to work with this file, type in the **number 4** and press **Return.**

10. The **Remove files menu** will appear on the screen. Press **Return.**

11. The **Organic Pies menu** will appear. You do **not** want to save the changes made, so type in the **number 3** and press **Return.**

12. Answer **yes** to the question "Do you really want to do this?" at the bottom of the screen by using the **right arrow key** and **Return key.**

AppleWorks File Organic Pies

Note: This is a *MacWrite* copy of an *AppleWorks* file for use with the Introduction to *AppleWorks* Database 2 worksheet.

Column 1	2	3	4	5	6	7	8	9
Apple Light	4000	2000	Jul 4 84	16,000	4000	4.00	3.00	1.00
Carob Crunch	3600	900	May 5 84	14,000	5004	3.89	2.50	1.39
Coconut Custard	2800	700	May 5 84	12,000	2884	4.28	3.25	1.03
Crispy Cotton	20	20	Aug 14 84	80	40	4.00	2.00	2.00
Granola Pudding	200	50	May 5 84	800	400	4.00	2.00	2.00
Kumquat	600	150	May 5 84	3,600	600	6.00	5.00	1.00
Pisco	5	3	Jul 4 84	20	1500	4.00	1.00	3.00
Pure Peach	800	400	Jul 4 84	3,200	1200	4.00	2.50	1.50
Ragamuffin	500	250	Jul 4 84	2,000	750	4.00	2.50	1.50
Rhubarb	400	200	Jul 4 84	1,600	800	4.00	2.00	2.00
Squash Blossom	400	200	Jul 4 84	1,600	400	4.00	3.00	1.00
Strawberry Strip	460	200	Aug 14 84	1,600	450.8	3.48	2.50	.98
Vegetable	285	100	Jul 4 84	1,200	487.35	4.21	2.50	1.71
Very Berry	6000	1500	May 5 84	24,000	6000	4.00	3.00	1.00
Yogurt Yummy	1250	300	Jul 4 84	3,675	1175	2.94	2.00	.94
Zucchini	200	50	May 4 84	800	500	4.00	1.50	2.50
zzzzzzzzzzzzzzz	1000	1000	May 14 88	25000	4000	4.00	3.00	1.00

When you make up these files, you need the following information to type into the record.

==

1. Pie Name
2. Units Sold
3. Units/Month
4. Date Introduced
5. Total Sales
6. Total Profit
7. Price/Unit
8. Cost/Unit
9. Profit/Unit

==

Introduction to *AppleWorks* Database 3

1. Remove the *AppleWorks* disk from disk drive 1. Put in the **Apple Presents** *AppleWorks* **side 2** disk into drive 1. Close the disk door and press the **Control, Open-Apple** and **Reset** keys **simultaneously.**

2. A **menu** will appear on the screen with the **Word Processor** highlighted. Type in the **number 3** and press **Return.**

3. Another **menu** will appear with **Cutting and Pasting** highlighted. Press **Return.**

4. Go through **all** three sections and take **notes** when necessary as you will be sending some information to a friend using the word processor and database.

When you have finished, take out the **Apple Presents** *AppleWorks* disk and insert **side 1** of the *AppleWorks* disk. Load up *AppleWorks* and get the **Software 86** file from the **AW Sample Files** disk on the screen.

1. One of the nice features of a database is that you can select certain information from a large file.

2. Your friend wrote you a letter and wants to know all the software that you have available for math. The only list you have for your district is the one on this file. Rather than print out the entire list and send it to her, you've decided to send her a list with just the math software.

3. Look through the file and see if you notice a way to categorize the math software. Write down any ideas here.

4. Now let the computer do some of the work. You can select criteria that *AppleWorks* uses to select records. Press the **Open Apple** and **R** keys simultaneously. That's for record selection rules.

5. You now have a list of the categories for the records. Pick a category that you think will be able to cut down on the list of software and press **Return.**

6. Now a list of comparisons appears on the screen. Pick one of the comparisons and press **Return.** For example, say you picked **Program Name** as a category. Now you might pick **contains** and then type in the word **math.** This would tell the computer to look at all the **names** of the software in the file and if it contained the word **math** in it, you wanted it.

7. You can have up to three selection criteria. You can decide what categories and comparisons to use. When you finish, you will have a list on the screen that fulfills your set of criteria.

8. Now you want to **save** this file (if it is not the file you want, start over until you have the file you want). Press the **Escape** key to get you back to the **main menu.**

9. Type in the number 3 and press Return. **Software 86** is listed as changed. Press **Return. Save the file...** is highlighted. Press **Return.**

10. **Let the old** ... is highlighted. You do **not** want it to replace the original file, so type in the **number 2** and then press **Return.**

11. Use the **right arrow key** to go to the right of **Software 86** and delete the name by using the **delete key**. Now type in a **new name** that **you** would like to save this information under and press **Return.**

12. You now have a file of math software under a new name. Once you have **saved** the file, the **main menu** appears on the screen. In order to **print** out your list, type in the **number 2** and press **Return** to get back to your file.

13. Now your file should be on the screen. Since several of you are connected to the same printer, make sure you print one at a time. Press the **Open Apple** and **P** keys at the same time in order to print.

14. Now that you have a hard copy of your file, press the **Escape** key to go back to the **main menu.** You want to check your list against the original list, so type in the **number 4** to remove your file. A screen telling you that you have saved your file will appear. Press **Return.**

15. Now the main menu is again on the screen with **Add files...** highlighted. Press **Return** and load **Software 86** again.

16. Just for your own information, check to see how well your criteria was in terms of getting all the math software. List problems, thoughts and observations here.

17. Now to practice cutting and pasting! Press the **Escape** key to get back to the **main menu**.

18. Press **Return** (**Add files...** should be highlighted). This time, you want to make a **new** file from the word processor, so type in the **number 3** and press **Return.**

19. **From scratch** should be highlighted so press Return. Type in a name for this file (A letter will do if you're stuck for a name).

20. Now you have a typewriter in front of you, so type a letter to your friend and add your list of software from the database. When you are finished, print the letter out. (There is a "help" page following this one on cutting and pasting.)

Software 86 *AppleWorks* File

Note: This is a *MacWrite* file copy of an *AppleWorks* file for use with the **Introduction to *AppleWorks* Database 3** worksheet.

Acquisition Num	Program Name	Publisher	Subject	Topic
C20000	IBM REPORTING A	IBM	-	-
C20001	PERSONAL EDITOR	IBM	-	-
C20002	IBM DOS 2.10	MicroSoft Corp.	-	Disk Operating
C20003	IBM DOS 3.10	MicroSoft Corp.	-	Disk Operating
C20004	IBM FILING ASSI	IBM	CS	File Utility
C20005	IBM FILING ASSI	IBM	-	-
C20006	APPLE SUPER CO-	Alpine Computin	-	Pilot
C20007	IBM DOS VERSION	MicroSoft Corp.	-	Disk Operating
C20008	APPLE SUPER PIL	Apple Computer	CS	Authoring Langu
C20009	MICRO GARDENER	Educational Act	AG	Growing Plants
C20010	dBASE III	Ashton-Tate	CS	Database
C20011	APPLE LOGO	Logo Computers	CS	Programming Log
C20012	GUIDE TO OPERAT	IBM	CS	Intro. to IBM
C20013	BASIC 2.0	MicroSoft Corp.	CS	Basic Programmi
C20014	BASIC 3.0	IBM	CS	Basic Programmi
C20015	Speech Regonit	Keytronics	-	Speech Recognit
C30000	Treasure Hunter	Grolier	History	-
C30001	Secrets of Scie	Grolier	Science	-
C30002	Play Writer Adv	Woodbury	English	Writing
C30003	Calculated Risk	Woodbury	Science/m	Archaeology
C30004	Play Writer Ta	Woodbury	English	Writing
C30005	The Story of Mi	Grolier	English	Vocabulary
C30006	Surrounding Pat	Strawberry Hill	Math	Visual Patterns
C30007	Peters Growing	Strawberry Hill	Math	Graphic & Number
C30008	What's Next	Strawberry Hill	Math	Analyzing Patte
C30009	Miss Mouse	Grolier	Reading	Rhyming
C30010	Rhyme Land	Grolier	Reading	Concept of Rhym
C30011	Rhyme-A-Line	Grolier	Reading	Rhyme Vocabular
C30012	Moon Bingo	Grolier	Reading	Vocabulary Buil
C30013	Rhymo's Falling	Grolier	Reading	Vocabulary Buil
C30014	Arith-Magic	QED	Arithm	Area and Prime
C30015	Arith-Magic	QED	Arithm	Area and Prime
C30016	The Semantic Ca	Sunburst	Math	Problem Solving
C30017	Tobbs Learns A1	Sunburst	Math	Puzzles, Proble
C30018	The Factory	Sunburst	Math	Strategies in P
C30019	The King's Rule	Sunburst	Math	Math and Discov
C30020	Geometric Suppo	Sunburst	Geometry	Quadrilaterals
C30021	The Geometric S	Sunburst	Geometry	Triangles
C30022	Teasers by Tobb	Sunburst	Math	Puzzles, Proble
C30023	Targets (Teache	Sunburst	Math	Numbers
C30024	The Incredible	Sunburst	Math	Problem Solving
C30025	Master Match	Advanced Ideas	Learn Skill	Memory and Reas
C30026	Tic Tac Show	Advanced Ideas	Learn Skill	Testing Knowled

C30027	The Game Show	Advanced Ideas	Learn Skill	Vocabulary, thi
C30028	Dinosaurs	Advanced Ideas	Learn Skill	Matching
C30029	Wizard of Words	Advanced Ideas	Language	Reading, spelli
C30030	Lucky's Magic H	Advanced Ideas	Learn Skill	Reading and Mem
C30031	Typing Tutor	Academy Software	Typing	Touch typing
C30032	Typing Tutor	Academy Software	Typing	Touch typing
C30033	Typing Tutor	Academy Software	Typing	Touch typing
C30034	Typing Tutor	Academy Software	Typing	Touch typing
C30035	Decimal Series	Quality Educati	Math	Decimals
C30036	Proportions and	Quality Educati	Math	Proportions and
C30037	Machines, Work	Educational Act	Science	-
C30038	Heat and Light	Educational Act	Science	-
C30039	The Structure o	Educational Act	Science	-
C30040	Electricity and	Educational Act	Science	-
C30041	Whole Numbers	Educational Act	Math	Add, Sub, Mult
C30042	Tables 1-12 Ro	Educational Act	Math	Rounding Off Nu
C30043	Fractions: Addi	Educational Act	Math	Addition and Su
C30044	Decimals: Add	Educational Act	Math	Decimals
C30045	Graphs and Mean	Educational Act	Math	Graphs, Mean
C30046	Converting Frac	Educational Act	Math	Fractions and P
C30047	Measuring with	Educational Act	Math	Perimeter, Circ
C30048	Basic Writing S	Educational Act	English	Writing
C30049	Basic Writing S	Educational Act	English	Writing
C30050	Magic Slate (Te	Sunburst	Wrd Proc	80 Clmn Ve
C30051	Magic Slate (Te	Sunburst	Wrd Proc	20/40 Clmn Ve
C30052	Diascriptive Re	Educational Act	Reading	Diagonistic Test
C30053	Diascriptive Re	Educational Act	Reading	Vocabulary
C30054	Diascriptive Re	Educational Act	Reading	Reading Sequenc
C30055	Diascriptive Re	Educational Act	Reading	Main Idea
C30056	Diascriptive Re	Educational Act	Reading	Fact/Opinion
C30057	Diascriptive Re	Educational Act	Reading	Details
C30058	Diascriptive Re	Educational Act	Reading	Inference
C30059	Learning with F	Sierra	Math	Counting
C30060	Wizmath	Sierra	Math	-
C30061	Wiztype	Sierra	Typing	Typing Skills
C30062	Homeword Writer	Sierra	English	Writing Spelling

The records that you will need in order to create the above file in *AppleWorks* includes:

1. Acquisition Number
2. Program Name
3. Publisher
4. Subject
5. Topic
6. Machine
7. Copyright Date
8. Grade
9. Price
10. Backup Info
11. :
12. # Labels

Cutting and Pasting Files

1. In the Word Processor, type your letter until you get to the place where you want to insert the data information.

2. Press the **Open Apple** and **Q** keys at the same time.

3. A list of files should appear on the screen. Use the **up** or **down arrow** key to highlight the Database file you want and press **Return.**

4. Your database file should now be on the screen. Press the **Open Apple** and **P** keys at the same time. *AppleWorks* will give you some options. You want **#1 - Get a report format.** It should be highlighted, so press **Return.**

5. A list of options will appear and you want **#1** - **CATE Sftwr by Sbjct,** which should be highlighted. Press **Return.**

6. A screen full of options will appear. All you are interested in at this point is to print this file, so press the **Open Apple** and **P** keys at the same time.

7. You want this file printed to the clipboard, so type in the **number 4** and press **Return.**

8. Since there is a date on your letter, you do not need one here, so press **Return.** A message telling you that the report is on the clipboard will appear. To continue working with the Database file, you would press the Space Bar. However, you want to get back to the letter, so press the **Open Apple** and **Q** keys at the same time.

9. Use the **up** or **down arrow** keys to highlight your letter and press **Return**.

10. Now you should be back in your letter. Place the cursor where you want the database to be copied by using the Return key or Space bar.

11. Press the **Open Apple** and **C** keys to copy the information. Use the **right arrow key** to highlight from the clipboard and press **Return.**

12. Your file should now be in your letter. Use the **down arrow key** to get to the end of the data and finish your letter. You may print the letter out if you wish.

Name: ______________________________

Game of the Week

Many students think of mathematics as "A bunch of formulas to memorize and to use to solve problems." To a certain extent this is correct. Mathematicians have developed a very large number of formulas that can be used to solve quite a range of problems. But, which of these should students memorize, and what are alternatives to memorizing formulas?

One answer lies in learning to make use of books of formulas. For example, instead of memorizing a formula for the volume of a sphere, one learns the general concept that solids have volume, and that formulas exist for the volume of commonly occurring and "regular" solids. Rather than memorizing a large number of formulas, one learns to look up the needed formulas.

Pick one or two classes and make a list of the formulas you teach for that class (or for you non-math teachers, formulas that you know). Now look for common characteristics, descriptors, or some other way of associating fields of information that would be useful to you or your students in dealing with a database containing these formulas. A few possible fields might be: should it be memorized (yes, no), week number taught, course it is taught in, number of variables, area formulas, interest formulas, differentiation formulas, often used in physics courses (yes, no), and so on. The idea is to begin to think about the development of classification schemes that are appropriate to you and your students.

Game of the Week Outcomes

Note: This is not intended as a handout. Rather, it is a brief discussion to give the inservice facilitator some ideas on what outcomes may be expected from the Game of the Week.

Many of the participants simply listed formulas for various mathematical ideas and left it at that. They did not seem to be able or willing to develop a classification scheme that would be useful to themselves or their students. A few participants tried to form some sort of grid so that formulas that are taught in more than one class could be shown.

The essential formulas listed were:

Formulas with two variables

- Area and perimeter formulas
- Percent formulas
- Distance and work formulas
- Velocity formula
- Difference in time zones
- Temperature change formula

Formulas with more than two variables

- Volume formulas
- Interest formulas
- Analysis and trig formulas
- Proportion formulas
- Line formulas
- Surface area formulas
- Right triangle and other geometry formulas
- Quadratic formula

In the debriefing of this game it was evident that many of the participants had not given much thought to information retrieval aspects of mathematics. Few participants were able to categorize formulas in a manner useful either to themselves or to their students. The game and discussion did give several participants a chance to see the different formulas they teach and where they coincide for certain classes.

4.5.5 Materials

These sample lesson plans are designed to be used with students at a variety of grade levels. They represent the types of activities that can be done with students after learning the material in Session 5.

Inservice facilitators may want to use some of these materials during the session. If the session is more than two hours in length, it is appropriate to have participants work through a number of these student activities.

Included in this section is a more detailed performance aid that facilitators may wish to use if there is more time available. It is on creating forms and reports from an *AppleWorks* database.

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(LP) Tombstone City 9

Database Record Selection

(or How Do I Get the Records I Want?)

Databases are convenient ways of storing information. The power of them is not just in storing the data, but in the ways the data can be manipulated. This reference will examine four **Open Apple** commands for manipulating data. None of the following commands delete or lose any of the information in the database. They only rearrange or choose specific records for examination or printing.

Arrange (**Open Apple A**)-Sorts information in four possible ways:

1. Alphabetically, beginning with A. This is represented on the menu by "from A to Z."
2. Alphabetically backwards, beginning with Z. This is represented on the menu by "from Z to A."
3. Numerically, from smallest to largest. This is represented on by menu by "from 0 to 9."
4. Numerically from largest to smallest. This is represented on the menu by "from 9 to 0."

After placing the cursor on the column to be sorted, enter **Open Apple A**. Select the desired option and press **Return**.

Find (**Open Apple F**)-Finds the desired pattern of characters (numbers, letters, and special characters) *wherever* they appear in the database. This does *not* depend on the column the cursor is in when the **Open Apple F** command is entered. The whole database is searched and the entire record containing the desired pattern is returned. You can think of this as being somewhat like the Search command in a typical word processor.

Select (**Open Apple R**)-Allows for the selection of records based upon searching specific fields using a wide variety of comparison options in combination with Boolean operators such as **and** and **or**. For example, suppose that one had a file containing used autos, the year built, and the number of miles on their odometer. With this database it would be possible to find all the Toyotas built after 1977 that have greater than 100,000 miles.

Enter **Open Apple R** and the category names of the database are presented. Choose the name of the category to be examined. Press **Return** and a long list of options appears. Select the desired option and press **Return**. If this is the only selection criteria then press **esc** (escape). Otherwise, choose the next selection criteria. Press **Return** after each selection. When all criteria have been entered, press **esc.** To retrieve the entire original database press **Open Apple R** and select **yes**.

The above commands can be used from REVIEW/ADD/CHANGE in either the multiple-record or single-record formats. It is common to use these commands in the multiple-record layout because the results appear on the screen together, rather than one at a time as in the single-record format.

The fourth command discussed in this handout is called Calculate and allows you to specify certain types of calculations to be performed on the numerical data in a database. To use the command, enter **Open Apple P**. This enters the Report Format routine of the database. Select number 2 - Create a new "tables" format, press **Return**, enter a name for the report, and press **Return**. After you have created a report format it will automatically be saved when the database is saved.

In the Report Format routine you will be able to use both Arrange and Select from above, as well as Calculate described below.

Calculate (**Open Apple K**)-Calculate allows a new category to be created, which contains information from other categories. Simple arithmetic operations are performed on a category (or combinations of categories) in the database and the results entered into the new category.

Place the cursor one column to the *right* of the category where you wish the calculated results to appear. Enter **Open Apple K.** A new column filled with 9's automatically appears. Enter a name for this category and press **Return**. Enter the formula or calculation to be executed. Operations are performed from left to right. Parentheses are *not* accepted. Press **Return** and answer the questions on the bottom of the screen. Finally the database will reappear, but with the 9's still present. Enter **Open Apple P** and select number 3 - The Screen. The calculated category(ies) will appear.

There can be up to three calculated categories. The calculations in creating a calculated category may make use of any *noncalculated* categories, and they may also make use of calculated categories. However, the calculations in creating a calculated category may only use other *calculated* categories that are to its left.

The fundamental underlying ideas of a spreadsheet and a database are rather closely related. Generally speaking, a spreadsheet is designed to contain a preponderance of numbers and formulas that manipulate the numbers. That is, a spreadsheet is designed to be quite powerful at calculations. A typical spreadsheet may have no or relatively poor searching and sorting capabilities, the features that a database system is designed to handle well. On the other hand, a typical database system may have relatively poor computational capabilities. The Calculate features described above fall into the "relatively poor" category.

Databases: Creating AW Forms and Reports

Note: This long handout contains considerable detailed information about databases in *AppleWorks*.

Creating a Form

1. Once you have decided on the field names for your database, you are ready to create an *input form*. Obtain a data disk and a copy of the *AppleWorks* program. (If the disk upon which you wish to store the data is not yet formatted, you can format it within *AppleWorks* by choosing the **Disk Formatter** function from the **Other Activities** menu.) Start the *AppleWorks* program and move to the **Main Menu**. Select item **1** (**Add Files to the Desktop**).

2. From the **Add Files** menu, select item **4** (**database**). From the **database** menu, select **1** (**From Scratch**). Type in the name of your database at the prompt on the bottom line of the screen.

3. Now you see the (**Change Name/Category**) screen, which you will use to create and edit forms. It has two parts: a space for typing in field names (called **Category Names** in *AppleWorks*) and a space containing a summary of commands (**Options:**) for creating forms. Note that in the **Category Name** space, there is already a field name (**Category 1**). Erase this by moving the cursor to the end of **Category 1** with the **right-arrow key**, then press the **Delete** key until the entry is erased. **Note:** In the upper right corner of the display, there is a note that if you press the **Escape** key, you can restore the entry you are deleting or changing.

4. Type in the field names one at a time, pressing **Return** after each entry. Note that the contents of the **Options** space change when you first press **Return**. When you have typed in the last field name and have pressed **Return**, press the **Escape** key.

Typing in Records

5. You now see the **Review/Add/Change** screen. Read the note in the center of the screen, which reminds you that this is a new database. Press the **Spacebar**.

6. Now you can fill in the form on the **Insert New Records** screen. Type in the entry after each field name and press **Return**. Note that when you type in the last entry and press **Return**, you will automatically move to the next empty record.

Viewing Individual Records and the Whole Database

7. When you finish typing in the last record, press the **Open Apple Z** key. This will give you a "zoomed-out" view of the entire database (or at least the first part of each record). Experiment with moving the cursor to different parts of the database and zooming in and out with **Open Apple Z**. In *Sample Screens #1 and #2* (see the last pages of this guide), you see an example of "zoomed-in" and "zoomed-out" views. Note that all seven fields can be seen in the "zoomed-in" view, but the last two fields are not in view in the "zoomed-out" view. When you are finished, press the **Escape** key.

8. Now you have returned to the **Main Menu** screen. You could stop working with the database now if you wished; the database you have just created will remain on the Desktop while you work on another one or create another document with the word processor or the spreadsheet. We will continue with it, however. Note (in the upper-right corner of the screen) that if you press **Escape**, you will return to the database you created. Press **Escape** and return to the database.

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Enter **Open Apple R** and the category names of the database are presented. Choose the name of the category to be examined. Press **Return** and a long list of options appears. Select the desired option and press **Return**. If this is the only selection criteria then press **esc** (escape). Otherwise, choose the next selection criteria. Press **Return** after each selection. When all criteria have been entered, press **esc**. To retrieve the entire original database press **Open Apple R** and select yes.

The above commands can be used from REVIEW/ADD/CHANGE in either the multiple-record or single-record formats. It is common to use these commands in the multiple-record layout because the results appear on the screen together, rather than one at a time as in the single-record format.

The fourth command discussed in this handout is called Calculate and allows you to specify certain types of calculations to be performed on the numerical data in a database. To use the command, enter **Open Apple P**. This enters the Report Format routine of the database. Select number 2 - Create a new "tables" format, press **Return**, enter a name for the report, and press **Return**. After you have created a report format it will automatically be saved when the database is saved.

In the Report Format routine you will be able to use both Arrange and Select from above, as well as Calculate described below.

Calculate (**Open Apple K**)-Calculate allows a new category to be created, which contains information from other categories. Simple arithmetic operations are performed on a category (or combinations of categories) in the database and the results entered into the new category.

Place the cursor one column to the *right* of the category where you wish the calculated results to appear. Enter **Open Apple K.** A new column filled with 9's automatically appears. Enter a name for this category and press **Return**. Enter the formula or calculation to be executed. Operations are performed from left to right. Parentheses are *not* accepted. Press **Return** and answer the questions on the bottom of the screen. Finally the database will reappear, but with the 9's still present. Enter **Open Apple P** and select number 3 - The Screen. The calculated category(ies) will appear.

There can be up to three calculated categories. The calculations in creating a calculated category may make use of any *noncalculated* categories, and they may also make use of calculated categories. However, the calculations in creating a calculated category may only use other *calculated* categories that are to its left.

The fundamental underlying ideas of a spreadsheet and a database are rather closely related. Generally speaking, a spreadsheet is designed to contain a preponderance of numbers and formulas that manipulate the numbers. That is, a spreadsheet is designed to be quite powerful at calculations. A typical spreadsheet may have no or relatively poor searching and sorting capabilities, the features that a database system is designed to handle well. On the other hand, a typical database system may have relatively poor computational capabilities. The Calculate features described above fall into the "relatively poor" category.

Databases: Creating AW Forms and Reports

Note: This long handout contains considerable detailed information about databases in *AppleWorks*.

Creating a Form

1. Once you have decided on the field names for your database, you are ready to create an *input form*. Obtain a data disk and a copy of the *AppleWorks* program. (If the disk upon which you wish to store the data is not yet formatted, you can format it within *AppleWorks* by choosing the **Disk Formatter** function from the **Other Activities** menu.) Start the *AppleWorks* program and move to the **Main Menu**. Select item **1** (**Add Files to the Desktop**).

2. From the **Add Files** menu, select item **4** (**database**). From the **database** menu, select **1** (**From Scratch**). Type in the name of your database at the prompt on the bottom line of the screen.

3. Now you see the (**Change Name/Category**) screen, which you will use to create and edit forms. It has two parts: a space for typing in field names (called **Category Names** in *AppleWorks*) and a space containing a summary of commands (**Options:**) for creating forms. Note that in the **Category Name** space, there is already a field name (**Category 1**). Erase this by moving the cursor to the end of **Category 1** with the **right-arrow key**, then press the **Delete key** until the entry is erased. **Note:** In the upper right corner of the display, there is a note that if you press the **Escape** key, you can restore the entry you are deleting or changing.

4. Type in the field names one at a time, pressing **Return** after each entry. Note that the contents of the **Options** space change when you first press **Return**. When you have typed in the last field name and have pressed **Return**, press the **Escape** key.

Typing in Records

5. You now see the **Review/Add/Change** screen. Read the note in the center of the screen, which reminds you that this is a new database. Press the **Spacebar**.

6. Now you can fill in the form on the **Insert New Records** screen. Type in the entry after each field name and press **Return**. Note that when you type in the last entry and press **Return**, you will automatically move to the next empty record.

Viewing Individual Records and the Whole Database

7. When you finish typing in the last record, press the **Open Apple Z** key. This will give you a "zoomed-out" view of the entire database (or at least the first part of each record). Experiment with moving the cursor to different parts of the database and zooming in and out with **Open Apple Z**. In *Sample Screens #1 and #2* (see the last pages of this guide), you see an example of "zoomed-in" and "zoomed-out" views. Note that all seven fields can be seen in the "zoomed-in" view, but the last two fields are not in view in the "zoomed-out" view. When you are finished, press the **Escape** key.

8. Now you have returned to the **Main Menu** screen. You could stop working with the database now if you wished; the database you have just created will remain on the Desktop while you work on another one or create another document with the word processor or the spreadsheet. We will continue with it, however. Note (in the upper-right corner of the screen) that if you press **Escape**, you will return to the database you created. Press **Escape** and return to the database.

Adding Records

Note: Initial the back of the paper forms which you have entered and pass them to the training group on your right. Accept the paper forms from the training group on your left. Use these forms to add records to your database.

9. Move the cursor to the end of the last record in your database and press **Return**. You will see a message in the center of the screen reminding you that you can add records to the database by selecting **Yes** as your response to the prompt on the bottom line.

10. Follow the sequence of steps 6-8 until you have added all the records you want.

Note: Obtain other paper forms and pass yours on until you have 5-6 records in your database. Now take some time to consider what kinds of questions you might ask about this information. Can it be grouped or sorted in useful ways?

Generating "Table" Reports

11. Press **Open Apple P**. This will take you to the **Report Menu**, which you will use to create report formats. A *format* is a way of laying out the information so that the printed report will be useful. There are several options on the screen:

    1. **Get a report format:** This is not highlighted, since you haven't created any formats yet.
    2. **Create a new "tables" format:** You will use this in a moment to create a report in tabular form; that is, a report in which the information is laid out in rows and columns.
    3. **Create a new "labels" format:** You will use this later to create a report in which the information can be laid out in blocks. For example, you would use this function to prepare mailing labels.
    4. **Duplicate an existing format:** There are times when it is useful to create a report that is a variation on a format that already exists. You can save a lot of work and avoid making errors by duplicating an existing format and changing it to meet your needs.
    5. **Erase a format:** Use this function to eliminate report formats which you no longer need.

12. Select Item **2** (**Create a new "tables" format**) and press **Return**. Type in a name for the report at the prompt on the bottom line.

13. Now you see the **Report Format** screen, which you will use to create a tabular report format for your database. Note the large block of "reminders" in the center of the screen. At the bottom, you can see the field names and the first three records of your database. If there are seven or more fields in your database, you will see only the first two letters of the seventh field, and any other fields will be "off-screen" to the right. See *Sample Screen #3*.

14. Use the **right-arrow** key to move the cursor to the rightmost column of your report. (If you had some columns off-screen, this will bring them into view.) Note that to the right of the last column there is an indication (under the vertically-printed letters **Len**) of how many columns wide the report would be if you were to print it out right now. Most printers can only print 80 columns unless special preparations are made. Press **Open Apple P.**

15. Now you see the **Print The Report** screen, which you will use to select the device on which the report is to be printed. *AppleWorks* may be set up to send reports to many different kinds of printers. Many printers require special setups; if you are using *AppleWorks* on a system whose printer does not appear on the **Print The Report** screen, you may have to go to the **Other Activities** screen to select the **Printer Information** function to add your printer to the choices on this screen. If you must do that, all will be well, because your database and the format that you are preparing now will remain on the Desktop. For now, though, select **The Screen** as the place to print the report and press **Return**. Type today's date (if you wish) at

the prompt at the bottom of the screen and press **Return**. This will print the report onto the computer screen in exactly the same way that it would appear on a printer. This function is useful for checking what a report will look like without actually taking the time to physically print it out. See *Sample Screen #4*. Note that you may have some columns in which there is insufficient room to display the information, while there is too much room in others. Press the **Spacebar**.

16. You can change the width of any column by moving the cursor (by means of the **right arrow** and **left arrow** keys) to the column you wish to change. If you wish to widen the column, hold down the **Open Apple** key and press the **right arrow** key until the column is wide enough. You can narrow the column by pressing the **Open Apple left arrow** key combination. Try printing the changed report to the screen by following the directions in step 15.

17. You can also eliminate a whole column if you wish by moving the cursor to that column and pressing **Open Apple D**. If you wish to restore a column which you have deleted to its former position, move the cursor to the column which had formerly *followed* the deleted column, then press **Open Apple I**. You will then see the **Insert a Category** screen, which lists all the categories which have been deleted. Select the one you wish to restore by highlighting it and pressing **Return**. It will reappear in its former position.

    You can use a similar method to move a column to a new location in the report. Just delete it with **Open Apple D**, move the cursor to the new location, then restore the column with **Open Apple I**.

    Another way of moving columns is by switching adjacent columns with **Open Apple >** and **Open Apple <**.

18. Experiment with other functions. Use **Open Apple A** to sort on particular columns. If you have numbers in any columns, right-justify them with **Open Apple J**. (Don't be disturbed when *AppleWorks* replaces all your numbers with **9999999.99**; that's just the program's way of telling you that something special is being done with the numbers.) Arrange for the report to add up any numeric columns by using **Open Apple T**. *Sample Screen #5* shows a format for a report listing debtors in decreasing order of indebtedness, with the amount owed by all totaled. *Sample Screen #6* shows what the report looks like when it's printed on the screen.

    When you have finished experimenting with tabular reports, press **Escape**.

Generating "Label" Reports

19. You should now see the (**Report Menu**) screen. Select Item **3** (**Create a new "labels" format**). Type in the name of the label-style report you intend to create and press **Return**.

20. This version of the (**Report Format**) screen lets you create block-oriented reports like mailing labels. You can move the field names to different places on the screen by placing the cursor on the first letter of the field name, holding down the **Open Apple** key and using the **arrow** keys (any of them).

    You can delete categories or blank lines with **Open Apple D**. You can insert blank lines and previously deleted fields with **Open Apple I**.

    If you want to print mailing labels, you can put the city, state, and zip code neatly on the same line by using **Open Apple J**, which will left-justify the information so that it will print just one space to the right of the data which precedes it in the line.

You can arrange for both the field name and its data to be printed on the report by using **Open Apple V**. This can be useful if the information is not self-evident.

Sample Screen #7 shows what the fields look like before they are formatted. *Sample Screen #8* shows a finished format. *Sample Screen #9* shows a "zoomed-in" view of one record (a handy way of getting an idea of what one "block" of the finished report will look like).

Experiment with some of the other functions in this formatter. You can view your options by pressing **Open Apple ?**.

21. Print the report by pressing **Open Apple P** and selecting **The Screen** from the (**Print the Report**) screen. *Sample Screen #10* shows what the first three records in the sample file look like when they are printed on the screen.

Building a Data Table
(A Database Pre-Computer Activity)

Description:

Topic: Explores the transition from data organization, fields and records into table format
Grade Level: 3-12
Time: 20-25 min.
Grouping: Whole Class & Groups of 4
Objectives:

1. Students will create a record
2. Students will identify the fields in the records
3. Students will create a table using the records

Materials:

Other materials: butcher paper, 5x8 cards, masking tape, felt tip pens
Software: None—needed

Before you start:

- Gather felt pens and 5x8 cards
- Tape the butcher paper to the wall
- Select the category for record generation—animals, sports, book titles, rock stars, food (fo this write-up, animals will be used)
- For greater variety in record generation, assign a letter of the alphabet to each group.
- For example, a group with the letter **P** might create a record for **python**, **platypus**, or **polar bear**. Another possibility might be type of animal: mammal, reptile, fish, etc.
- Organize the class into groups of 3 or 4.

Lesson: (Sequence of instructional activities)

- Each group brainstorms all the information on an animal of their choice. They record the information in any fashion on a piece of paper. A quick check around the room determines if there has been any duplication. (5 min.)
- Whole group discussion-the important characteristics of the animals e.g., habitat, number of legs, mammal, domestic, etc.
- The teacher demonstrates how data on an animal can be recorded on a card.
- Record the field names the students determine on the chalkboard. Have the students suggest an organization for the 5x8 cards.
- Hand out the 5x8 cards and the felt tip pens. Students organize each record on the card. Now, all the cards together become a file of records

Follow-up:

- Students create files for their own personal STUFF.
- The next time a report is assigned the students, use the new organization device for recording and gathering information.

Tombstone City

Thanks to Jim Rae

Description:

Topic: Gathering information, posing hypotheses
Grade Level: 5-9
Time: 4-5 days, 15-20 min./day
Grouping: 3-4 students per group
Objectives:

1. Students will gather information from a cemetery
2. The information will be organized and stored in a database
3. The data will be analyzed and hypotheses posed

Materials:

Software: a database manager
Equipment: one computer
Other materials: one cemetery

Before you start:

- Select a cemetery that your students can easily visit
- Assign student groups
- Determine with students which data should be recorded from the tombstones. Items could include: birth data, date of death, number of years lived, first name, last name, sex, inscription, picture, shape of stone... .
- Create a data gathering sheet with the field names that correspond to the database headers.

Lesson: (Sequence of instructional activities)

- Each student group gathers information for at least five headstones.
- Students type in the data into a database.
- All the data is complied into one file.
- Analyze the data and ask questions: Did many people die in a particular year? Did the average number of years lived vary according to sex? Was it more customary to have crosses on tombstones before a particular date?

If any patterns or ideas emerge, follow them up by gathering more data: checking encyclopedias, old newspapers, a different cemetery.

Follow-up:

Create a story about one of the tombstones. Explain why the person with that tombstone died during that year, at that age, etc.

What are some events that would affect the kind of data gathered from tombstones: changes in the economy, world wars, influenza epidemic, etc.

Have students predict how tombstones will read in 100 years.

Comments:

. This may not be a desirable subject for some students, but it can offer a wealth of material about the community in which students are growing up.

4.6
SESSION 6: GEOMETRY AND VISUALIZATION

4.6.1 Narrative Overview

Teaching three-dimensional geometry using two-dimensional media is a very common occurrence. And most math teachers have difficulty in doing good three-dimensional drawings on the chalk board or overhead projector foil. It's no wonder students have a hard time trying to understand what a section of a cone looks like, or even what a rectangular prism is!

Although computer screens are still a two-dimensional form, their ability to display three-dimensional figures should help students visualize objects in three-dimensional space. With proper software, these two-dimensional representations of three-dimensional figures can be rotated, viewed from different perspectives, shaded to help suggest their three-dimensional nature, etc. Such use of computer graphics has become common in science research labs.

Studies have shown that with practice, one's ability to visualize becomes better. We are now able to allow students to create and manipulate two-and three-dimensional objects using the computer and specific software. The programs we use for this session exemplify such software.

One question that arises with the availability of such software is: Should teachers change their method of geometry instruction? Many will say no due to our set curriculum—a certain amount of material must be taught in a given time frame, and discovery and inquiry methods are more time-consuming methods of instruction.

We disagree. The ideas given in this session are a way for students to discover geometric theorems and definitions by themselves, making the meanings much more real to them. We believe that students will retain what they learn through this method and will apply the same type of questioning skills in other areas.

A focus of this session is using a computer to do a lot of the "hands- on" construction. Because of the speed of the computer, students can construct figures and make observations without the time-consuming process of actually drawing with a pencil and compass. This allows students to make conjectures and see if they can prove or disprove those conjectures.

One software program,*Super Factory,* looks at a cube from one viewpoint and rotates it to see all faces. It is a game (with various levels of difficulty) in which the computer generates a cube with different "pictures" on the sides. The student must then figure out how to recreate the cube by rotating and turning a second cube and putting the various pictures on that cube. This requires visualizing the entire cube and what you must do in order to recreate it.

The *Geometric Supposer* series allows students to do a variety of constructions on triangles, quadrilaterals, and circles. Students can use the software to do constructions and come up with their own definitions for altitude, median, etc. Once these definitions are in place, students can work with them to "discover" theorems and try to prove and/or disprove them. One student from a high school in Boston, MA, actually discovered a new theorem! He found a new way to construct five triangles of equal area in a given triangle using the *Geometric Supposer-Triangles*. It may not be possible to teach an entire geometry course with computers, but integrating them into the curriculum will help to bring understanding and discovery into the course.

Geometry by Broderbund is a Macintosh-based piece of software that uses the graphics in a hypertext-type of presentation of geometry materials. It allows the user to move parts, find examples, do problems and proofs, and page back and forth. It follows a standard geometry curriculum and does not have the same discovery approach as the Supposer series. It provides a nice way for students to review or catch up on work missed when the teacher does not have time for individualized instruction. The graphics capabilities help to introduce three-dimensional objects much better than a standard textbook.

There are new and exciting pieces of software coming out for geometry. Anything that works with practicing visualization will help to improve students' abilities. It is not an easy task for many students, so the more they practice, the better they will become!

Most secondary schools in the United States follow the "traditional" mathematics curriculum of a year of algebra followed by a year of geometry and then a second year of algebra. Schools in most other parts of the world integrate these three courses, and there is some movement toward this idea in the United States.

The traditional geometry course in the United States has heavy focus on plane Euclidian geometry and on formal (two column) proofs. There are many good alternatives to such a course. One alternative is to place increased emphasis on those aspects of geometry where computers are particularly useful. The use of Logo in schools provides an example of what can be done. Or, one might teach some graphics-oriented programming using other languages, such as BASIC or Pascal. Such revisions to the classical geometry course are exciting.

But the use of computer programming in geometry courses poses a major problem. Most secondary school mathematics teachers have relatively little knowledge of computer programming. They do not have adequate preparation to deal with computer graphics in a computer programming environment.

An alternative approach, which has a greater chance of adoption, is to make very powerful graphics application packages available to both teachers and their students in geometry classes and in all other secondary school mathematics classes. Software of this type can be explored in an inservice session.

4.6.2 Script

Theme

Visualization skills and use of computer graphics in mathematics.

Objectives

1. Experience activities which enhance three-dimensional visualization skills.
2. Explore geometry and pose problems using computer-assisted constructions.
3. Cover the rules of logic using educational computer games.

Materials

Software	***Handouts***
The Factory	*The Factory* (LP)
Super Factory	*Colors of a cube*
Gertrude's Puzzles	Gertrude is a Pretty (LP)
High Wire Logic	Pentominoes (Facilitator must provide; paper ones are OK)
Geometric PreSupposer	*Geometric Activities* (WS)
Geometric Supposers Triangles	*Gertrude's Puzzles* (PA)
Geometric Supposers Quads	*Supposers* (PA's)
Geometric Supposers Circles	

Refreshments

Pre-Class

Load a puzzle from *Gertrude's Puzzles* into each computer. As participants arrive, get them started on this software. (*Note*: This same software was used in the Problem Solving Session. Here the emphasis is on spatial visualization which is a very important aspect in solving many types of problems.)

Introduction
Pentominoes
5-10 Minutes

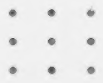
Purpose: Explore use of math manipulatives in geometry.
Hand out the pentominoes without saying what they are.
What do all of these pieces have in common? Observe as participants play with these mathematical manipulatives. Listen to what participants say to themselves and to each other. Encourage them to verbalize what they are conjecturing and learning. (If activity lags, you might suggest that they try to arrange their pentominoes into a rectangular shape. You might ask if it is possible to arrange them into a square, using all of the pieces.)

Debrief
5 Minutes

What roles do such math manipulatives play in geometry instruction? Are they mainly suitable for use in the elementary school grades, or are they also useful at the secondary school level? Are there some other math manipulatives that the participants commonly use in teaching geometry or other secondary school math topics?

Activity
5 Minutes

Ask participants to draw a three by three square grid of dots on a piece of paper. Then ask them if it is possible to draw a connected line path consisting of no more than four straight line segments in a manner that passes through each dot at least once.



Discussion
5 Minutes

Debrief the activity. The answer is YES, but for many this is a difficult exercise. The difficulty lies in setting a mental boundary on the problem To solve the problem, one must allow the line segments to go outside the boundary of the large square that the dots define. We want students to solve problems and often they will put extra conditions on the problems. How can we break down some of these barriers, boundaries?

Activity
15 Minutes

Purpose: Experience logic games in pictorial format. Instructions on overhead or board or handout:

- Press the space bar and Gertrude flies away.
- Solve the puzzle
- Press the space bar and do the same puzzle again.
- What is the optimum strategy for solving this puzzle?
- If time permits, try another room.

Debrief

What grade level are these activities appropriate for?
Where does this fit into geometry?
What might we mean by the concept of mental images providing physical boundaries for abstract ideas?

Demonstration
10 Minutes
The Factory

Purpose: Practice whole group visualization activity. Use a large screen monitor or computer projection system. Make a product explaining the three types of machines.
Point out the Test the Machines option on the menu.
(*Note*: The Factory was used during the Problem Solving Session earlier in this inservice series. It is an excellent piece of software for helping students practice a number of important ideas in problem solving. But it is also an important piece of software for giving students practice in spatial visualization.)

Alternative

Demonstrate The Super Factory.

Break;
Collect Logs

Activity
Super Factory
The Factory
15 Minutes

Purpose: Participants practice visualization skills using either *SuperFactory* or *The Factory*. Participants work in pairs to solve the problems.

Discussion 5 Minutes	Debrief the activity. What was the computer useful for? Where does this skill fit in the curriculum? Where is this skill useful? Mention Pat McClurg's dissertation and Billy Yate's dissertation. Both of these research projects suggested that use of The Factory is helpful in developing the spatial visualization skills of students. Was the activity interesting?
Activity 45 Minutes Geometric Geometric Activities (WS)	**Purpose**: Participants will explore geometric relationships. Load the *Supposers* and hand out the Geometric Activities (WS). Put the performance aids on the appropriate computers. Let them explore.
Debrief 10 Minutes	How does this type of tool affect the Geometry curriculum? Can also discuss possible project ideas.

Debrief last week's Game of the Week
Introduce this week's Game of the Week

4.6.3 Timeline

This sample timeline for a two-hour inservice is based on the materials in Section 4.6.2. Have a large-screen monitor available for this session, one or more Macintosh computers for use with *Geometry* from Broderbund, and paper circles already cut out for the first activity or scissors available so that people can cut out their circles as soon as they arrive.

0:00-0:10	Pentominoes exercise. Have a set of pentominoes (cut from stiff paper is OK) to give to each participant as they arrive. Do not give them any directions. Or, give bare minimum directions such as "Why don't you play with these fro a while while we wait for the rest of the people to get here."
0:10-0:15	Debrief this exercise. Emphasize the value of having aids to spatial visualization and manipulation.
0:15-0:25	Have Gertrude's Puzzles loaded onto the computers before participants arrive. As soon at the previous activity is completed, get participants working on this piece of software. Emphasize that they pay special attention to how a computer with its flat screen display can be used to display three dimensional objects.
0:25-0:30	Debrief. How "good" are the computer graphics in this piece of software? What would make them better? Are they good enough so they do not distract from working with the problems in this program?
0:30-0:40	**Demonstration.** Class activity using *Super Factory*. Have the entire class work on a challenge problem after a brief explanation.
0:40-0:45	Debrief. What was the computer useful for? How does this type of software affect the geometry curriculum? Does it? Should it?
0:45-0:55	Debrief last week's Game of the Week. Briefly describe the software stations that will be available for participants to work at after the break.
0:55-1:05	**Break.** Collect logs and Game of the Week sheets. *Load the Supposer's series and Geometry* into appropriate computers. Leave *Super Factory* loaded for those interested in playing with it.
1:05-1:50	Allow participants to go to the various stations. There should be time for participants to get an initial exposure to two different pieces of software. At each workstation there should be one or more "experts" (participants who have had a chance to work with the software during the previous week) to help answer questions.
1:50-2:00	Debrief. Now that they have seen the software, can it be integrated easily? Is hardware and access still the main problem, or teacher insecurity? With the software available, especially *Geometry,* will students be able to "catch up" on their own? Will they use the software for demonstration and class activities?

4.6.4 Handouts

This section includes handout materials needed by the participants during Session 6 of the Math Inservice. The facilitator may find it useful to make some of these into overhead projector foils for use during the inservice.

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Geometric Supposer: Triangle 2
Geometric Supposer: Quadrilaterals 3
Geometry 3
Game of the Week 4
Results of Game of the Week 5

Super Factory

(Grades 4-12)

Super Factory is a problem-solving three-dimensional visualization game. It is designed to teach several important problem-solving strategies: working backwards, analyzing a process, determining a sequence, visual reasoning and rotation.

Super Factory consists of three levels:

1. **Research** - allows students to explore three dimensional objects. Students can "play" with a three dimensional cube; they can try returning the cube to its starting position.
2. **Design** - Allows students to plan a strategy and execute it.
3. **Challenge** - confronts the students with a problem to solve. They must duplicate the pictures on the faces of a cube.

Super Factory comes with three programs, a diskette, a teaching guide and a back-up diskette. There are versions for Apple, Atari, Commodore, TRS-80, and IBM computers. *Super Factory* is available for $59 from Sunburst Communications, Room D 7575, 39 Washington Ave., Pleasantville, NY 10570, Phone (800) 431-1934.

Geometric preSupposer: Points and Lines

(Grades 4-12)

The *Geometric preSupposer* is a program designed primarily for learning and teaching geometry in the elementary and middle school grades. The *preSupposer* enables the user to carry out constructions and to draw segments, circles, angle bisectors, perpendiculars, and parallels, as well as measure and do arithmetic combinations of those measures.

There are seven menus and five submenus which allow for ease of use in creating geometric drawings. The *Geometric preSupposer* comes with a diskette, teacher's guide, reproducible activity sheets and a back-up diskette. It is available for the Apple computer. The *Geometric preSupposer* is available for $99 from Sunburst Communications.

Geometric Supposer: Triangles

(Grades 7-12)

The *Geometric Supposer: Triangles* is a program that allows the user to relatively easily carry out a variety of constructions that are possible using a straightedge and compass. These include construction of triangles as well as the drawing of segments, medians, altitudes, parallels, perpendiculars, perpendicular bisectors, angle bisectors, and inscribed and circumscribed circles. In addition, the user can measure lengths, angles, areas, and distances as well as the arithmetic combinations of these measures. Of course, it takes a fair amount of effort to learn to tell the computer to do these constructions.

This program provides students with a tool to learn about properties of triangles and to make measurements, change scale, and repeat experiments. Students can make conjectures about triangles and experiment to see if they are true or not.

There are seven menus and five submenus which allow for ease of use in creating geometric drawings. The *Geometric Supposer: Triangles* comes with a diskette, teacher's guide, reproducible activity sheets, and a back-up diskette. It is available for the Apple computer. The *Geometric Supposer: Triangles* is available for $99 from Sunburst Communications.

Geometric Supposer: Quadrilaterals

(Grades 7-12)

The *Geometric Supposer: Quadrilaterals* is a program that allows the user to relatively easily carry out the types of constructions that are possible using a straightedge and compass. These include construction of quadrilaterals as well as the drawing of segments, parallels, perpendiculars, angle bisectors, and inscribed and circumscribed circles. In addition, the user can measure lengths, angles, areas, and distances, as well as the arithmetic combinations of these measures.

This program provides students with a tool to learn about properties of quadrilaterals and to make measurements, change scale, and repeat experiments. It allows students to make any construction they wish on any quadrilateral. The program records that construction as a procedure that can be executed with any other quadrilateral. The user can explore whether the consequences of a given construction are dependent on some particular property of that quadrilateral or if the result can be generalized.

There are seven menus and five submenus which allow for ease of use in creating geometric drawings. The *Geometric Supposer: Quadrilaterals* comes with a diskette, teacher's guide, reproducible activity sheets, and a back-up diskette. It is available for the Apple computer. The *Geometric Supposer: Quadrilaterals* is available for $99 from Sunburst Communications.

Geometry

(Grade 9-college)

Geometry is a Macintosh program that helps to illustrate and/or teach many of the classical topics in plane geometry. It follows a classic geometry curriculum. It reviews, amplifies, and complements a year long geometry course. It has a blend of tutorial material, over 350 problems and proofs, and special interactive animation that allows you to experiment with the basic concepts of geometry. It also has a specially developed module that gives extensive practice and assistance with proofs.

Geometry comes with two disks and a User's Guide. *Geometry* is available for the Macintosh. It requires a 512K (or up) Macintosh or Macintosh Plus and an external drive. *Geometry* is available for $99.95 from:

Broderbund
17 Paul Drive
San Rafael, CA 94903
(415) 479-1700

Name ________________

Game of the Week

Do either 1 and 2 together, or 3 by itself.

1. The "changing process" can be very difficult. How do you feel about the changes a computer can make in your curriculum? Excitement, resistance, fright, more trouble than it's worth, etc., are all natural feelings. Please be honest. If it will help, leave your name off and just make sure I know you turned this in next week.

2. Do you think software writers should write more programs like *Geometry* from Broderbund (essentially a textbook in computer form, but with all the advantages of computer graphics)? Why or why not? Would you tend to use software of this form over others? Why or why not?

3. (*Optional Game of the Week*) Richard Bandler and John Grinder are psychotherapists who have developed a field of study that they call Neuro Linguistic Programming. They have written a number of books on this topic. A good introduction to their ideas is provided in *Frogs into Princes: Neuro Linguistic Programming* published in 1979 by Real People Press, Box F, Moab, Utah 84532.

   Bandler and Grinder suggest that people have a variety of methods of accessing and processing information, with visual, auditory, and kinesthetic being the most important. Some people have visual as their primary acquisition/processing mode, while others have auditory or kinesthetic as their primary mode.

   Research in mathematics suggests that being quite good at visual acquisition/processing of information is related to being good at mathematics. This type of research may suggest that students who are good at visual acquisition/processing of information may be good at geometry.

   Bandler and Grinder's research indicates that one can often pick out people whose primary mode of information acquisition/processing is visual by observing their eye movements as they answer questions such as "What color is the top of the three lights at a stop light" and "What color was the rug in the living room in the house you lived in when you were in grade school?" Visually oriented people tend to move their eyes up (look up and to the right, or up and to the left) when attempting to answer such questions).

   This Game of the Week is an experiment. Observe the eye movements of students as you ask them such questions. Note which students have eye movements up and to the right or up and to the left. Then attempt to relate this to how good they are in geometric aspects of the math curriculum you teach.

Results of Game of the Week

(*Note*: This is not intended to be a handout. Rather, it gives the inservice facilitator an indication of the types of responses that participants might provide in responding to the Game of the Week.)

There are two choices for this week's game. The results for both follow:

1. The "changing process" can be very difficult. How do you feel about the changes a computer can make in your curriculum?
    - excitement
    - problem-solving
    - still have to learn the basics
    - frustration because not enough hardware or software available
    - difficult because of time needed
    - infusion of fresh ways to work on a problem
    - refocusing of what is really important in math
    - scheduling problems for use of computers
    - will allow students to address conceptual matters in a more relaxing and fun manner
    - difficulty in finding the right software to do what is needed
    - teacher training needed
    - necessary preparation a hassle
    - need someone who can "troubleshoot" on short notice
    - need lab assistant(s) and money
    - a good tool for student use
    - still considered a toy by students who want to "play" games
    - may be more trouble than it's worth
    - chance to create the future and help decide what uses are best
    - challenging to integrate
    - at this point, it will add to a teacher's workload
    - at this point, ideal circumstances are not available in terms of hardware, software, help, etc., so too much extra work to ask of a teacher
    - learning to use the tool is not a priority at this point
    - motivation for teachers is difficult because of time involved

2. Do you think software writers should write more programs like *Geometry* from Broderbund? Why or why not? Would you tend to use software of this form over others? Why or why not?

    - Yes, if instructions were easy to follow.
    - Yes, as a tutorial. One great advantage to using computers is to get away from textbooks!
    - Can see some applications, but need to see more programs before a decision can be made.
    - Yes, the graphics are very nice and students can understand better.
    - Yes, for independent working students. Nice form for review or catch up, but until it is available for all, not very practical.
    - No, software should be an addition to a textbook.
    - No, it's too limiting. Computers (software) should keep up with the changes, not be like a textbook that is behind the times in terms of curriculum changes.
    - No reason to have a computer replace a textbook.
    - Yes, as a resource room tool where a student can get extra help.
    - Yes, the visual effects were excellent! Much easier for a student to understand than a standard textbook.

3. Primary accessing mode—eye movement.

    - In a middle school low level math class, the top students tended to look up, whereas the rest tended to look down rather than sideways.
    - In a high school geometry class, the top students tended to have a lot of eye movement, not necessarily always looking up. Students with average to below average grades tended to have less eye movement.

4.6.5 Materials

These materials in this section are designed to be used with students at a variety of grade levels. They represent the types of activities that can be done with students after learning the material in Session 6.

Inservice facilitators may use of some of these materials during the inservice session. If the session is more than two hours in length, it is appropriate to have participants work through a number of these student activities.

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Gertrude is a Pretty Smart Ol' Goose

Description:

Topic: Logic and Patterns
Grade Level: 2-12
Time: 10-30 Minutes
Grouping: Pairs of students
Objectives: Different for different levels

Materials:

Software: *Gertrude's Puzzles*
Equipment: Computer and color monitor
Other materials: Attribute blocks

Before you start:

Determine the goals according to the level of the students. At the beginning levels it is useful to use attribute blocks before and after using the computer.

Lesson: (Sequence of instructional activities)

1. Students practice moving the green square and exploring the rooms. It is easier and quicker to use a joystick than the keyboard.
2. Students learn how to play each of the games (six in all) one at a time, with whole class discussions after all students try a particular room (game). After discussing the strategy used and what was learned, students return to try that same room and improve their logic skills.
3. Determine the optimum strategy for each of the rooms.
4. Determine the least number of steps for solution in each room.
5. Determine all the possible solutions given a specific set of pieces and a puzzle.
6. Use the shape editor to design new pieces.
7. *Off-line*: have students design board games that are similar to Gertrude's rooms.
8. Students keep a map as they traverse the rooms. A complete map is quite complex.
9. How many distinctly different variations are possible for each of the rooms? Consider both the combinations of puzzle pieces and the distinctly different solutions.

Post:

1. Game theory can be explored at many different levels. For example, how often does Gertrude bring a blue diamond? Determine all the distinctly different combinations possible using the given set of pieces.
2. Design a set that has more than one piece that looks alike. What happens? What real life situation does this simulate?
3. Have students design games with game pieces, rules, and randomness.

Comments:

This is often treated as a child's game - too simple for older children. Often the reverse is true. It appears to be simple and yet many of the rooms are challenging.

In addition to the logic, patterns, and attribute training, the laws of probability, combinations, and permutations can be explored extensively. Once students have learned the strategies and have discussed and compared them, go on to programs that allow students to build challenging games; for example, *Pinball Construction Set, LodeRunner*, or *Planetary Construction Set*.

Geometric Activities

Listed below are some geometrically oriented exploratory exercises that can be done with students at a variety of grade levels. For many of these, the Geometric Supposer software would be quite useful.

1. Look at five isosceles triangles or five rhombuses (or five of anything) and make a definition based on comparing and contrasting lengths of sides and degrees of angles, perimeters, and areas. The idea here is to give students five different examples of something (such as an isosceles triangle) and ask them to write a definition that encompasses all five examples, but that is as narrow as possible. Thus, students seeing five different isosceles triangles might write a definition "A closed, connected figure made from three line segments." But that definition holds true for all triangles, so is not narrow enough.

2. Draw a triangle on the board. Ask students to draw a line parallel to the triangle. Ask them to draw a line perpendicular to the triangle. Have them make up a "reasonable" definition of what it might mean for a line to be parallel or perpendicular to a triangle. The same exercise can be done starting with other geometric figures.

3. Draw a triangle, any triangle, select a label category, and reflect the whole figure. Does the reflected triangle have the same area? same angles? Justify your answers.

4. Sums of angles: Either compare the sum of angles in a variety of triangles (right, acute, obtuse, isosceles, and equilateral) or quadrilaterals (parallelogram, trapezoid, kite, and random). Compare the sum of the exterior angles. Look for patterns and generalizations.

5. Construct a triangle. Draw a median and compare the areas of the two smaller triangles. Compare the perimeters. Repeat these steps for at least two more triangles. (This requires more thought using certain pieces of software than others).

6. Start with any random quadrilateral. Connect the midpoints of the sides consecutively. What can be said about this smaller quadrilateral? Repeat these steps for at least two more quadrilaterals. (This requires more thought using certain pieces of software than others).

7. How does a central angle compare to an inscribed angle in a circle?

8. Find a circle with the same area as a square. That is, start with an arbitrary (unspecified size) square. Then using the standard straight edge and compass construction techniques, construct a circle with the same area as the square.

9. Trisect any angle. That is, start with an arbitrary (unspecified size) triangle. Then using the standard straight edge and compass construction techniques, divide the angle into three equal angles.

4.7

SESSION 7: INVERTED CURRICULUM

4.7.1 Narrative Overview

With computers becoming increasingly available in schools, a major question that keeps popping up is: Should we continue to teach the "conventional" mathematics topics in the order that we are teaching them now? Computers are allowing much younger students to do "more difficult" mathematics on an intuitive level. Computers can help students address problems that traditionally are kept from them until their later mathematical years.

Graphing data or functions and solving equations are typical examples that come up when people discuss an inverted curriculum. An inversion occurs when we teach a student to use computer tools to accomplish these tasks before we teach how to accomplish the same task by hand. Indeed, students may learn machine methods for some tasks for which they never learn manual methods.

It is generally agreed that problem solving is indeed something that mathematics teachers want to encourage in students as young as possible. Even before calculators and computers, we have questioned whether to teach students to use certain tools and ideas before they fully study and understand the underlying theories. Computers merely add another dimension to this question. Can students "understand" what they are doing when a calculator or computer does much of the work? Can/should students really solve problems using tools and ideas that they do not fully understand? Teachers who have used computers in the classroom as an exploratory tool are amazed at how much math younger students can discover if left to their intuitive abilities with just a few hints or a little help now and then. So the question becomes: When do we teach which concepts?

We don't have an answer. But it seems to make sense that if students at younger ages are able to "discover" some mathematics, they should not be held back or told they have to wait until later before they can do those types of problems. This will mean a rearranging of curriculum and scope and sequence.

The mathematics education community works at curriculum change both from a top down and a bottom-up approach. Attempts to implement "new math" represent a top down approach. Much of the current calculator use in the curriculum has come about through a bottom-up approach.

Most use of computers in the math curriculum has come about through a bottom-up approach. Many individual math teachers are taking the time and effort to learn how to use computers and are using their knowledge in their teaching. If we wait for a directive from the country, state, county, or even the district level, it will likely be quite some time before anything will happen. Eventually, the larger entities will catch up with what is going on in the individual schools and classrooms and will mandate reform of some type. But those who are on the leading edge want to make changes now.

This particular session focuses on what an individual teacher or individual school can to implement computer-related changes in the mathematics curriculum. Changes in mathematics education do not happen quickly. Therefore, we take the optimistic attitude that *any* change that occurs because of this inservice is a step in the right direction. If all this session does is make a participant aware that she or he is capable of implementing a very small change, it will be a success. Rarely will a participant leave this inservice and become a prophet or "instant integrator" of computers into the curriculum. With that thought in mind, facilitate the debriefings by getting ideas and suggestions from all participants, and be aware that just thinking about change is a major step for many participants.

4.7.2 Script

Because of the special nature of this session, it isn't appropriate to prepare a detailed script. This session is designed primarily as a sequence of small group and large group discussions. It emphasizes getting participants to more fully understand that using the computer as a tool allows the "inversion" of the order of teaching many topics. Computers allow a major shift in emphasis in what it means to learn a topic.

The NSF inservice had a number of participants from each school, and it had participants from a number of schools. Thus, in small group discussions it was appropriate to divide participants up by schools or by the particular types of math courses they teach.

The first approach lays foundations for continued meetings of the math staff in a particular school. Since not all math staff from a school were participating in the inservice, any change involving the whole staff would have to be based on whole staff meetings at the school.

The second approach to dividing participants into groups allows coordination between schools. If there are to be significant changes to the math curriculum in a school district, there will need to be a lot of coordination among all of the schools. Since not all schools were represented in the inservice, a number of additional meetings involving the wider audience would be needed.

If participants have not already read Section 1.1 " What the Research Literature Says" about change in education, assign it as reading to be done before the current session. It gives foundational information about change in education, what works and what doesn't.

Vivian Johnson's Ph.D. dissertation work, which was based on long term evaluation of this NSF project, suggests that it is quite important for a school to have a long-range plan for computers in the school. Schools that have such plans tend to make more instructional computing progress over a period of years than schools lacking such plans. Thus, one central focus of the current session could be the laying of groundwork for getting each school to develop its own long-range plan for computer use throughout the entire curriculum. For more information on long-range planning, you might want to read *Long-Range Planning for Computers in Schools* written by David Moursund and Dick Ricketts. It is published by Information Age Education, 1250 East 29th Place, Eugene, Oregon 97403-1621. The phone number is (503) 345-1575.

4.7.3 Timeline

This sample timeline is for a two-hour inservice session. Have an overhead projector available. There was no computer use for this session.

An alternative approach to devoting a specific session to the inverted curriculum is to introduce such ideas throughout the sequence of inservice sessions.

0:00-0:25	Introduction to the idea of an inverted curriculum and possible futures of mathematics education. Present and have discussed an overall philosophy of what a teacher can do as an individual, a department, a school, a city, etc.
0:25-0:30	*Activity 1.* The participants should fill in the blanks "off the top of their heads."
0:30-0:45	Discussion. In groups of three, each from a different school, participants share and discuss their answers. They can use the back of the page for different observations, responses, questions, and concerns.
0:45-0:55	Debrief as a whole group. As other ideas, questions, and concerns come up, participants can note them on the back of their papers.
0:55-1:05	Break. Collect logs and Game of the Week.
1:05-1:15	Debrief Game of the Week.
1:15-1:20	*Activity 2.* As individuals, fill in the blanks, again off the top of their heads.
1:20-1:35	Part 2. Get together in school groups and discuss responses. Share ideas and thoughts. What does it mean in terms of the math curriculum? How can computers facilitate problem solving? What can you, as an individual teacher, do to bring about change in a smooth fashion? What do you see as changing in the future of math education? How can you convince others in your department/school/district that computers should be used as a tool? Do not spend time on "Lack of (hardware, software, books, trained teachers, etc.) ..." issues. Look at long range goals and positive steps that can be taken.
1:35-1:47	Each school will give a three minute synopsis of what their school came up with in terms of steps and activities they can do.
1:47-1:50	Announcements; reminder that participants will do their final presentations in the next session.
1:50-2:00	Fill out evaluation form. (The project evaluator used this time as part of the formative evaluation of the whole NSF project.)

4.7.4 Handouts

These handouts are needed by participants during Session 7. The facilitator may find it useful to make some of these into overhead projector foils to use during the inservice.

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MATH EDUCATION FOR AN INFORMATION AGE SOCIETY

Question: What could be done to make mathematics education more appropriate for students in our current and future Information Age society?

This handout consists of three distinct parts. The first part focuses on what can be done in the individual schools of the participants. The second focuses on school districts. The third focuses on what individual participants in the inservice sessions can do as individuals, as members of a school faculty, and as members of a district faculty. In a typical inservice session this handout might be used for three distinct activities. The first activity would focus on individual schools, and the first part of the "numbered" parts of the form given below, etc.

When requested to do so, please write very brief responses, giving your "off the top of the head" ideas. In each case the "a" response should not be computer-based and the "b" response should be computer-based. Do not go on to the second and third activities until there has been discussion and debriefing on the first activity.

1. (First Activity): What could be done in my school ?
   a. (*Not computer-based*)

   b. (*Computer-based*)

2. (*Second Activity*): What could be done in my school district?
   a. (*Not computer-based*)

   b. (*Computer-based*)

3. (*Third Activity*): What could I do in my own teaching to support ideas from 1. and 2. above?
   a. (*Not computer-based*)

   b. (*Computer-based*)

Name: ___________________

Game of the Week

1. For many students, the reward for "learning" their math comes much later in life. Ask several or all students in each of your different classes these questions.

   a. Why are you taking this math class?

   b. What do you expect to learn in this math class?

   c. Do you ever expect to have to use any of the **skills** you have learned in this class?

   d. Do you think that any of the math you have learned will help you in any way later on in your life?

Alternative Game of the Week

List or describe activities that you (the teacher) do in your classroom that can now be enhanced or made easier by the use of a computer as a tool. Pay particular attention to the idea of an inverted curriculum.

Game of the Week Outcomes

Note: This is not intended as a handout. Rather, it is a brief discussion to give the inservice facilitator some ideas on outcomes that may be expected from the Game of the Week. There were two choices for this week's game.

1. For many students, the reward for "learning" their math comes much later in life. Ask some students in each of your different classes these questions: a) Why are you taking this math class? b) What do you expect to learn in this math class? c) Do you ever expect to have to use any of the skills you have learned in this class? d) Do you think that any of the math you have learned will help you in any way later on in your life?

In answer to (a), middle school students responded mainly with:

- it's required
- to learn math
- to learn to be a grown-up
- to get a job
- for education
- to get a good grade as it's my favorite subject

High school math students answered similarly but also added statements such as:

- for college entrance
- it's required
- I don't know
- I relate to objects better than to numbers this was from a geometry student

In answer to (b), middle school students answered:

- math
- fun things
- how to do taxes
- how to use and understand math
- different ways of doing math
- learn to be better and faster at math
- algebra/geometry
- +,-,x√, fractions, decimals
- everything you need to know
- mental math
- math for jobs

High school math students said:

- geometry
- more about shapes and polygons
- how to do math
- constructions
- how to solve story problems
- a lot of things
- I don't know
- theorems
- formulas
- stuff to use in science courses

In answer to (c), middle school students responded:

- over 50% just said "yes" with no clarification
- I don't know
- in school
- at home
- balancing a checkbook
- figuring out my g.p.a.
- working with computers
- cooking
- working on cars, bikes, etc.
- at various jobs
- shopping
- helping my kids
- athletics/games
- business investments
- in math classes

High school math students answered:
- about 50% just said "yes" with no clarification
- yes, some of the skills will be used
- no, I will never need these skills once I finish this class
- I use it in science classes
- I will use it in the next math class

In answer to (d), middle school students answered:
- Over 50% answered "yes" with no clarification
- I don't know
- getting a job
- when I'm older
- reading a map
- depends on the job
- balancing a checkbook
- doing income taxes
- measurement
- no

High school math students answered:
- Basic skills are necessary for my future
- Yes (no clarification)
- I don't know
- I hope not

Alternative Game of the Week. List or describe activities that you (the teacher) do in your classroom that can now be enhanced or made easier by the use of a computer as a tool.

Middle school math teachers in 1986-87 answered as follows:
- gathering materials to use computers twice a week
- gradebook program
- computer makes more professional-looking teaching aids
- simulations
- produce graphs of data collected
- visual thinking/logical thinking
- geometry
- drill and practice
- use databases or spreadsheets in developing real life problems
- integration of math and science
- graphing of equations
- working with interest rates
- applications methods/ project

High school math teachers in 1986-87 answered as follows:
- statistics
- area under a curve
- constructions
- applications
- positive-negative numbers
- drill and practice
- problem-solving strategies
- graphing equations
- tutorials
- keeping records
- volumes
- proofs
- visual aids
- making worksheets, tests
- geometry—using software to have students generate hypotheses
- computer could do routine work while students do the thinking

4.7.5 Materials

These materials provide an alternative way to organize this session. The idea is to divide the participants into discussion groups, using the materials to focus the discussions. This approach divides the two-hour inservice into two parts. During each part, the groups carry on a discussion for about 30-40 minutes. Then there is a brief whole-group debriefing.

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Exercise 1 2
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Exercise 1

This is a role play exercise for a group with six or more participants. The six roles are parent, school administrator, math and/or computer teacher, department head, student, and district computer coordinator. In a discussion group, there should be one or more people assigned each role. A person assigned to a specific role should try to think and respond as that individual during the entire discussion. Questions and reactions should be spoken as a concerned, intelligent participant of this group.

Parent: Average parent from your particular school. "Math was hard for me, but I usually did my worksheets. I think that it was good for my brain."

Administrator: Concerned about parent, teacher, and student reactions to computers and the changing curriculum. "I have lived through a lot of changes that were going to make school better. Educational TV was one of them. I am always open to change, but I've been around the block more than once."

Student: Average student at your particular school. "I've been told that math is good for me and useful, but we don't seem to make much use of it outside of the math class. My parents want me to take it."

Math/computer teacher: Yourself. (Inservice participant to play him or her self.)

Department head: Yourself or how you think a department head may react. "I think we could be doing a lot better in terms of making our courses relevant, of interest to students, and of higher quality."

Computer coordinator: Your job is getting things together and moving. "If all students had good and easy access to computers, and if their teachers knew more about computers, our school system would be a lot better."

There should be a recorder and a chairperson for each group. The recorder should take down any questions or concerns so that they may be discussed during the second session. The chairperson should make sure that everyone has a chance to speak and express their ideas and concerns. In a meeting setting, discuss the impact of computers and how they might change the curriculum, and the problems, advantages, disadvantages, and concerns from your point of view. How will computers affect teaching in general? Hardware and software shortages may come up in the discussion, but they should not be a major focus point.

Exercise 2

Form groups on the basis of schools, grouping several schools together if necessary in order to have about 4-6 participants in each group. Each participant should assume the role of a mathematics education leader who is deeply concerned with improving the mathematics education system. (Think of yourself as a department head or as a person at the level of a district math curriculum specialist.) Have a recorder so that ideas can be brought up again during debriefing. Some of the topics or ideas that your group might talk about include:

- What do computers mean in terms of the math curriculum?
- What do you see changing in the future of math education? How will these changes lead to having a better mathematics education program?
- Problem solving has been stressed—how can the use of computers facilitate this? Can it?
- Can computers help in transfer of learning?
- How can you convince others in your department/school that computers should be routinely used as a tool?
- What can you, as an individual teacher, do to bring about the change in a smooth fashion?

The discussion might focus on coming up with a specific set of policy statements to be adopted by the policy makers of the school district. For example, a policy statement might be "We will provide all of our high school students with scientific calculators and allow their use on all tests they take except those statewide and national tests that specifically prohibit use of calculators." Another policy statement might be "All new math teachers we hire must be computer literate. All current math teachers will be expected to become computer literate during the next three years, and we will provide them with appropriate and adequate help in achieving this goal." The whole group debriefing at the end of the discussion time could then focus on a sharing of policy statements.

4.7.6 Readings

This section is designed to supplement the materials presented during Session 7. It is appropriate to assign these readings as homework for inservice participants.

Report of a Conference Sponsored by
the
National Science Foundation

COMPUTING AND MATHEMATICS

The Impact on Secondary School Curriculum
(Published in 1984 by NCTM)

James T. Fey, Editor
with
William F. Atchison
Richard A. Good
M. Kathleen Heid
Jerry Johnson
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NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

Impact of Computing On Algebra

(Reprinted with permission from the
National Council of Teachers of Mathematics.)

The secondary school mathematics program for college-bound students begins with, and is dominated by, topics from algebra. In the United States, a one-year course in elementary algebra introduces the concept of variable, the uses of variables to express quantitative relations, and procedures for manipulating expressions to solve simple linear or quadratic equations. A second one-year course extends these ideas and techniques to more complex situations, and for many students, further courses in advanced mathematics rely heavily on algebraic concepts and methods. For many students emerging from high school, mathematics is synonymous with algebra. It is not uncommon to hear calculus students exclaim, "I know what to do, but I'm hung up on the algebra."

The prominence of algebra in school curricula is not hard to explain. It is inconceivable that one could proceed very far in any branch of mathematics without the tools that algebra provides. The use of symbols for quantitative variables, operations, and relations provides an economy of expression that makes complex ideas easily communicated. Comparing the following algebraic forms from successive periods in the history of mathematics is convincing evidence of the value of modern notation (Cummins, 1969):

What must be the amount of a square, which, when twenty-one dirhems are added to it, becomes equal to the equivalent of ten roots of that square?	(Rhetorical, ca. 825)
cubus p' 6 rebus aequalis 20	(Syncopated, ca. 1545)
aaa - 3bba = +2ccc	(Symbolic, ca. 1631)

The modern symbolic notation is, of course, fundamental in the expression of scientific principles, formulas in technology and business, and the structural properties of number systems. Beyond mere expression of ideas, the symbolic forms and manipulative techniques of algebra have proven fruitful in the discovery of entirely new facts and principles. After modern symbolism appeared around 1600, mathematicians of the seventeenth and eighteenth centuries made awesome progress through daring formal manipulation of expressions. As Judith Grabiner (1974, 357) points out, the equation

$$(x - a)(x - b)(x - c) = x^3 - (a + b + c)x^2 + (ab + ac\ bc)x - abc$$

reveals relations between roots and coefficients of a polynomial that dozens of numerical examples might not. She suggests, "Relying on results like [the equation above], Albert Girard in 1629 stated that an nth degree equation had n roots -- the first formulations of what Gauss later called the Fundamental Theorem of Algebra." The power of symbolic notation was not limited to discovery in algebra. The Leibnizian notation for calculus, dy/dx and $\int y dx$, has proved an invaluable aid to thinking about problems of differentiation and integration. During the eighteenth century, Euler performed impressive algebraic gymnastics with infinite series leading to derivations like the power series expressions for cos x and sin x.

In addition to facilitating discovery, algebraic notation provides a valuable tool for the verification of intuition. Commenting on the role of symbolism in his work on the foundations of mathematics, Bertrand Russell observed, somewhat cryptically, that

> Symbolism is useful because it makes things difficult. Now in the beginning everything is self-evident, and it is hard to see whether one self-evident proposition follows from another or not. Obviousness is always the enemy of correctness. Hence we must invent a new and difficult symbolism in which nothing is obvious.
>
> (Bertrand Russell is quoted from one of his 1901 papers by R.E. Moritz [1958, 199].)

As the development of algebra progressed from mere "generalized arithmetic" to a broader concern for any of the structures imposed on sets by operations and relations, the abstract concepts of algebra have been useful in the unification of diverse branches of mathematics. Abstract algebra emerged as a twentieth-century development in pure mathematics, but its concepts and methods have now proved fundamental in physics, computer science, and related problem areas.

Given this record of impressive and fundamental contributions by algebra to all aspects of mathematics, there appear to be no grounds for a challenge to its central position in secondary school curricula. It is clearly the preferred language of expression in mathematics, and in applications of quantitative methods to other disciplines. So it would seem that students ought to learn as much as they can as soon as they can. Indeed, when mathematics faculty assess the current problems of college preparatory mathematics programs, they commonly recommend stronger preparation in the concepts and techniques of algebra. Nevertheless, current criticisms of school algebra are diverse and strong, and the potential impact of computing on algebra gives further support for a reexamination of the content and pedagogy of algebra in secondary schools.

Algebra in secondary school

Algebra has been an important part of the secondary curriculum for over a century. In 1820 Harvard University listed algebra as a requirement for admission. The Committee of Ten (1893) established algebra as an essential part of the curriculum, defining the course to include study through quadratic equations and radicals. The spirit of that course was elaborated by the Committee of Fifteen (NEA 1895):

> The algebra course in the secondary school . . . very properly begins with severe exercises with a view to discipline the pupil in analyzing complex literate expressions at sight and to make him able to recognize at once the factors that are contained in such combinations of quantities. (P. 58)

The emphasis on manipulative aspects of algebra has been tempered over the years by calls for attention to the applications and unifying structural ideas of the subject. In 1923 the National Committee on Mathematical Requirements of the MAA suggested that "the primary and underlying principle of the course . . .should be the notion of relationship between variables, including the methods of determining and expressing such relationship" (1923, 12). The committee took an entire chapter of their report to support and explain the meaning of using the function concept to unify the algebra course.

The 1959 College Board Commission on Mathematics and the 1963 Cambridge Conference on School Mathematics proposed modernization of the algebra course to include the deduction of algebraic methods from structural properties of the number systems. This "new math" view was frequently criticized as endorsing inappropriate abstraction, and in 1976 a joint NCTM/MAA committee report recommended that for college-bound students:

> Both understanding and competence in the skills of algebra are necessary. Neither conceptual understanding nor technical skill alone will suffice in today's world, let alone in tomorrow's. Algebra is a useful subject which will help to solve problems in the real world. (P.2)

This recent statement expresses well the persistent tension in school algebra between, on the one hand, attention to manipulative skills and the methods appropriate to such instructional goals and, on the other hand, attention to the broader structural ideas that underlie the skills and their usefulness in applied situations. The report glibly overlooks another persistent issue, the problem of finding genuine and convincing illustrations of "real world" applications for high school algebra. It seems fair to say that despite periodic reform efforts, the secondary school algebra curriculum has always emphasized training in the variety of procedures for transforming one expression into an equivalent and, it is hoped, more usable form. The common pedagogy is to demonstrate a procedural rule and then have students model that procedure in extensive practice exercises. When the procedural rules are justified, it is usually by some generalization of an arithmetic procedure learned previously or by some intuitive mnemonic like "2 oranges plus 3 oranges equal 5 oranges." The problem material is primarily a collection of traditional puzzles involving coins, ages, moving vehicles, or workers sharing a task. These various problem types are also commonly taught by presenting an algorithmic scheme for each. When skeptical teachers challenge the syllabus of instructional emphasis, they are assured that the skills are essential for advanced mathematics, especially calculus; when skeptical students balk at that argument, they hear that "algebra, like cod liver oil, is good for you -- try it, you may not like it, but rest assured, it is doing good things for you" (Higginson 1977, 1).

The iconoclasts of mathematics education have continually challenged weaknesses in the prevailing content and pedagogy of algebra. Most recently, Zalman Usiskin (1980) presented a shrewd analysis of topics that should *not* be in the first-year algebra curriculum of college-bound students.

1. Current world problems, though intended to teach translation of real-world conditions into mathematical form, are so contrived that they succeed only in teaching students that algebra "has no applications, that you should not use common-sense arithmetic to solve [problems], and that algebra is difficult" (p. 416).
2. Trinomial factoring of expressions like $ax^2 + bx + c$ is justified primarily as a procedure for solving quadratic equations; however, it is a method that works for only the very limited family of carefully planned examples that appear in textbooks. When the coefficients are not carefully chosen integers or the polynomial reaches a degree higher than 2, the carefully practiced procedures are of little use.
3. The addition, multiplication, and simplification of complex fractional expressions is a skill with utility for only a very limited number of students far in their mathematical future.

Although similar criticism has faced the school algebra curriculum in the past, the force of the arguments has been strengthened immeasurable by the emergence of computers and subsequent mechanization of so many routine mathematical operations that previously required highly trained human algebra machines.

Computers and algebra

The most accurate one-sentence summary of the goals for school algebra instruction would probably be something like this:

> Develop student skills in the solution of equations; finding numbers that meet specified conditions.

The methods available for such tasks are of two basic types: numerical and formal-symbolic. Numerical methods generally involve some form of sophisticated trial-and-error search planned to locate roots by successively finer approximations. Symbolic methods, however, involve transformations of the form of the equation to progressively simpler conditions, one of which makes the solution obvious and exact. The current and projected capabilities of computers will contribute powerful new tools for both approaches and thus raise important questions about the focus of school curricula.

Numerical methods in algebra. Conventional polynomial algebra offers several lines of attack on an equation like $x^2 - 5x + 3 = 0$. When attempts by factoring are stymied, one can complete the square or shortcut that process with the quadratic formula. Without computational assistance, estimating the roots (≈ 4.3 and ≈ 0.7) by trial and error would be tedious, if not completely discouraging. However, the method of successive approximation becomes much more attractive with a brief BASIC program:

```
10 INPUT A, B, C
20 FOR X = A TO B STEP C
30 PRINT X, (X - 5)*X + 3
40 NEXT X
```

A rough search RUN yields

```
?          -5, 5, 1
           -5          53
           -4          39
           -3          27
           -2          17
           -1           9
            0           3
            1          -1
            2          -3
            3          -3
            4          -1
            5           3
```

guaranteeing zeros in the intervals (0, 1) and (4, 5). As a bonus we have good ideas about the minimum point of the polynomial and solutions of the inequalities $x^2 - 5x + 3 \neq 0$. A refined search in (0, 1) requires a brief command to the active program.

```
RUN
?          0, 1, .2
           0           3
           .2          2.04
           .4          1.16
           .6           .36
           .8          -.36
           1           -1
```

and similar refinement locates this root more precisely.

The computer-based numerical approach to the solution of equations focuses on the polynomial $x^2 - 5x + 3$ as a function with many (input, output) pairs. This suggests looking at a graph of the function, a task for which most computers are now well suited. One of the many graphic packages available will ask the user to enter the function rule and set the scales on the x-y axes. Then a high-resolution graph is quickly produced (fig. 2.1). This graph (provided suitable scales have been chosen) yields good estimates for the zeros of the function and, as a bonus again, the approximate minimum point and *regions* of positive and negative value.

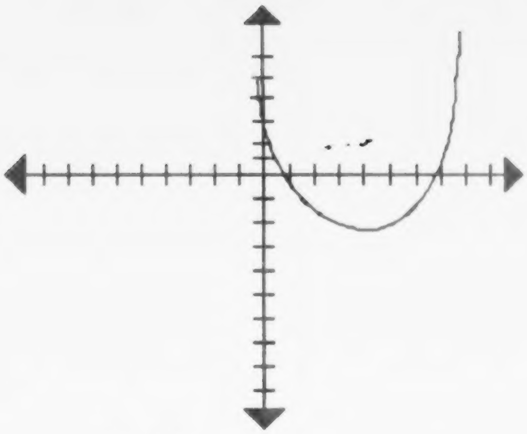

Fig 2.1

The numerical methods described above are not mathematically elegant, but they have several impressive virtues. First, the "guess and test" strategy seems incredibly easy to remember -- it is so natural. Long after students have forgotten the quadratic formula or developed bugs in their factoring skills, they will likely know enough to try successive approximation. Second, the method of successive approximations applies without a major change to the solution of nearly every type of equation, from higher-degree polynomials to rational, exponential, or trigonometric conditions. Third, the numerical approaches stress the functional point of view that is at the heart of most later applications of algebra -- in calculus, for instance.

There are, of course, more sophisticated numerical methods for solving algebraic equations. One of these methods has already been built into a scientific calculator (Kahan 1980). After entering the equation of interest and one or two first guesses at solutions, the press of a single "SOLVE" button sets the solution algorithm in motion. In essence, this calculator exploits a commonly used computer program that has been built into the machine -- saving each user the need to design and enter the program when needed.

The concept of stored scientific computational subroutines has been widely accepted and used on large machines for complex tasks like statistical analysis. The emergence of personal computers has stimulated the development of many more application program packages that will reduce the user's tasks to program selection and data entry. For instance, the popular electronic spreadsheets, pioneered by VISICALC, allow the user to enter a collection of related formulas, to vary the value of parameter, and to see immediately the effects of those changes on all the dependent quantities. A typical work session might proceed as follows:

I. Define relations.

	A	B	C
1.	PRICE		
2.	SALES	-400*B1 + 1400	
3.	COST	.2*B2 + 200	
4.	REVENUE	B1 * B2	
5.	PROFIT	B4 - B3	
6.			

II. Set price, with other terms calculated automatically.

	A	B	C
1.	PRICE	1.5	
2.	SALES	800	
3.	COST	360	
4.	REVENUE	1200	
5.	PROFIT	840	

III. Change price in B1; other terms change automatically.

IV. Project a sequence of price figures and see the matrix of corresponding projections displayed.

Although these spreadsheets seem specially appropriate for the application of related formulas in a business situation, another impressive package, *TK!Solver*, does equation solving very much like that of ordinary algebra. A typical session with *TK!Solver* might proceed as follows:

I. Enter equations on the "rule sheet."

Rule Sheet

Rule
$x = 2 - y$
$y * z = 12$
$z + w^2 = 30$

The program identifies variables and lists them on an accompanying variable sheet.

Variable Sheet

Input	*Name*	*Output*	*Unit*
	x		
	y		
	z		
	w		

II. When a value of one (or more) variables is specified, the program does whatever equation solving is needed to identify (where possible) the values of other variables.

Variable Sheet

Input	*Name*	*Output*	*Unit*
	x	-.4	
	y	2.4	
	z	5	
5	w		

As the headings suggest, when the variables have measurement units (dollars, kilograms, meters per second, etc.) and conversions between underlying quantities have been entered (e.g., miles to kilometers: multiply by 1.6), TK!Solver will make unit conversions automatically.

The solutions produced by TK!Solver employ techniques of ordinary algebra except, where necessary, numerical methods are also exploited.

In addition to the impressive equation-solving tools described already, computer languages and widely available utility programs facilitate computational aspects of algebra for systems of equations, linear programs, matrix arithmetic, and a variety of other important techniques in linear algebra. For instance, to solve a system of equations like

$$\begin{aligned} x + y + z &= 7 \\ 2x + 3y + z &= 18 \\ 3x + 4y + 2z &= 25, \end{aligned}$$

one would ordinarily need to recognize the problem type, call an appropriate program, and then enter the variables and coefficients to produce the solution:

```
x = 3 -2 * z
y = 4 + z
z = (ARB),
```

Thus, if the goal of algebra is the solution of equations and inequalities, available and easily projected computing hardware and software offer powerful new kinds of assistance. Reviewing TK!Solver, Gregg Williams (1982, 360) claimed that the new tool "does for equation-solving what the pocket calculator does for arithmetic -- replaces drudgery and the possibility for error with speed and accuracy."

Computer symbol manipulation. Despite the dominance of equation solving in school algebra, there is another very important side of the subject that depends on formal manipulation of algebraic expressions. For instance, the equation of coordinates for a straight line in the plane is commonly given in at least half a dozen equivalent forms. But each form is particularly suited to giving certain insights into the relation expressed by the graph. For instance:

- The slope-intercept form $y = mx + b$ quickly reveals the rate of increase in y. When x represents sales and y production costs, m and b give marginal and fixed costs, respectively.
- The point-slope formula $y = y_1 + m(x - x_1)$ is particularly illuminating in calculus for giving local linear approximations to a curve.

Thus, a student's algebraic skills should include not only numerical methods for "finding x," but also methods for transforming expressions into more convenient and revealing forms.

Software programs called computer-symbolic mathematics have been available on mainframe computers since 1953. The appearance of muMath, an interactive computer algebra package for microcomputers, has made the tools available to a broad audience of potential users. The muMath subprograms turn host micros into symbolic calculators with the following capabilities (among others):

- Exact arithmetic operations on integer, rational, algebraic, and complex numerals, with integer numerals up to 611 digits:

```
? 1/6 + 4/9
@ 11/18
```

(In the following example the notation #I is used for the square root of -1)

```
? (3 + 2*#I) * (6 - #I);
@ 20 + 9*#I
```

- Arithmetic functions like ABS, GCD, LCM, and ! are standard:

```
? GCD (24,60);
@ 12

? 12!;
@ 479001600
```

- Algebraic transformations of expressions invoving variables and operations (+, -, *, /, ^);

```
? SOLVE (M*X - X == 5, X);
@ [X == 5/((-1 + M)]
? SOLVE ((X - 2)/(X + 4) + (X - 1)/(X - 2) == 15/7,X);
@ [X == 3,
   X == -40]

? EXPD ((X = 2) * (X - 3));
@ -6 - X + X  ^ 2
? (18 * (A ^ 3)) ^ (1/2);
@ 3*A*(2*A) ^ (1/2)

? SOLVE (X ^ 2 - 5*X + 3 == 0,X);
@ [X == 5/2 + 13 ^ (1/2)/2,
   X == 5/2 -13  ^  (1/2)/2]
```

- Operations on matrices with numberic and nonnumeric elements; for instance, if A = $\begin{bmatrix} 1 & 0 \\ 2 & X \end{bmatrix}$,

  muMath calculates A ^ -1 as $\begin{bmatrix} 1 & 0 \\ 2/X & 1/X \end{bmatrix}$

- Logarithmic simplification and trigonometric transformations:

```
? LN (*E ^ X ^ 2);
@ X ^ 2
?  TAN (A) * COS(A) + 1/CSC(A);
@  2*SIN(A)
```

- Closed-form sums and products:

```
? SIGMA (3 * K,K,1,N);
@ 3*N*(N + 1)/2
```

(The muMath/muSimp-80 Symbolic Mathematics System Reference Manual for the Apple II Computer [1981]. See also Steen [1981]; Wilf [1982]; Pavelle, Rothstein, and Fitch [1981].) The important and impressive fact about all these symbolic computational capabilities is that the machine executes algorithmic procedures very similar to those that an expert algebraist would follow. The program has incorporated the manipulative routines of a very substantial course in algebra.

In 1970 Carl Engelman (1970, 103) envisioned "a mechanical assistant possessing an encyclopedic knowledge of mathematical formulae and results, capable of rapid and flawless computation, familiar with a broad spectrum of computational algorithms." In muMath, that assistant is very near. The creators of the muMath package made some daring predictions of consequences (*muMath/MuSimp-80 Reference Manual* 1981, 11-1):

> Some educators will undoubtedly feel that computer algebra will cause algebraic skills to atrophy or prevent them from developing in the first place. Similar concerns were undoubtedly expressed about Arabic numerals, multiplication tables, logarithms, Laplace transforms and pocket numerical calculators; but we have survived their convenience. The National Council of Teachers of Mathematics strongly supports the use of numerical pocket calculators in classrooms, and every reason for this support is even more true of computer algebra.

At this point in our experience with computers, the impact from classroom use of symbolic computation is uncharted territory. But the opportunities are impressive and the questions for research are of critical importance.

New directions for secondary school algebra

The computer capabilities described above are already widely available. As various mathematics educators have used and thought about these dramatic changes in the technology for assisting mathematical work, they have imagined a broad range of potential changes in the school algebra curriculum. Some see the opportunity to extend the content of current curricula, whereas others see the opportunity to teach traditional topics far more effectively.

In the late 1960s, the Colorado Schools Computing Science Group produced a prototype *Second Course in Algebra and Trigonometry with Computer Programming*. The goal of this innovative text was to gain experience needed to answer these questions: (1) Can the computer be used to improve the high school student's understanding of mathematics? and (2) How will the emergence of the computer affect the high school mathematics curriculum? The experimental text made several interesting deletions of content, including some factorization methods and simplification techniques. In retrospect, the teaching of a programming language was overemphasized at the expense of mathematical content, and the computer involvement was forced in places. Though this project was an important first step, it had little impact on the curriculum and it could not foresee and take account of the incredible advances in technology and software for mathematics.

Until very recently, the Colorado effort stood as the only major attempt to rethink the algebra curriculum in light of computing technology. Each possible approach to the assimilation or accommodation of the computer in school algebra has risks together with promise. Since there is little experimental work on which one can base judgments about the impact of major or even minor changes in curriculum, one is left with the task of identifying the options and the research-and-development questions raised by each option.

A New role for manipulative skills. When hand calculators became nearly universally available as aids to arithmetic computation, many mathematics teachers saw an opportunity to greatly diminish the attention given to training elementary school students in mechanical performance of complex algorithms for arithmetic. Computers seem to offer the same promise in algebra, diminishing the importance of developing student skill in algebraic manipulations.

What are the prime candidates for such reduced time on the high school algebra agenda? When this challenge is posed to mathematics educators, there is an immediate question: For which students are the new curricula intended -- what age, ability, and interest groups? It seems clear that the most able and interested high school students should continue to acquire most of the traditional skills and understandings of algebra. But considering the remaining students, it is not hard to reach an agreement on the following guidelines for change, using the usefulness of each concept or skill as a decision criterion:

1. Student ability to manipulate algebraic expressions into alternative, equivalent forms needs to cover only the simpler cases of useful operations -- those that are done more efficiently by hand than by machine, and those that are needed to give students an adequate understanding of the computer-generated results. For instance:

a) Properties of exponents like $x^n \, . \, x^m = x^{n+m}$ should be taught. Simple applications like

$$3^5 \, . \, 3^{10} = ?$$

or

$$(a - 2)^2 (a + 2)^5 = ?$$

seem appropriately done by hand, but there seems little need for student skill at simplifications like

$$\frac{40x^3y^2z^3}{x^5yz^9} \cdot \frac{xy^8z^{-5}}{6y^{10}z^{-3}}$$

b) Simplification of radicals like $\sqrt{20x^3y^6}$ and the procedures for rationalizing denominators seem of little importance.

c) Factoring of quadratic trinomials like $x^2 + 5x + 6$ and certainly more complex variations, seems unimportant; factoring using a single application of the distributive property , as in $ab + ac = a(b + c)$, seems valuable for students to learn.

d) Combinations and simplification of rational expressions beyond the simplest cases seem of little importance. For instance,

$$\frac{a}{b} + \frac{c}{d} = \frac{ad + bc}{bd}$$

should be known by most students, but skill with expressions like

$$\frac{2x + 2}{x + 1} - \frac{x + 4}{x + 3} + \frac{x + 2}{x + 3}$$

seems of far less importance. As a general rule, it seems reasonable that students should be able to perform, by hand, one-step applications of the basic properties governing algebraic expressions.

2. Likewise, it seems reasonable that students should learn equation-solving procedures that cover those cases most efficiently done by hand or those that provide a minimum understanding for the use of computer results. For instance:

a) Linear equations and inequalities in one variable should be readily solved by all students. Some procedure for solving quadratics (probably the quadratic formula) would open the access to a rich supply of important applications. There seems to be little need for students to learn all the traditional methods for solving polynomial equations or any but the simplest examples of rational and algebraic equations.

b) The notion of a system of equations and some basic tools for solving systems remain important, but techniques for dealing with complex cases seem of little importance.

The reasoning used in formulating such proposals for a change in algebra curricula is deceptively simple and plausible. Who could dispute the principle that students should learn that which they can do more efficiently than machines and that which will ensure the intelligent use of computers as algebra aids? The general strategy of reducing technical complexity in the tasks set for students seems to be a logical consequence. Unfortunately, the implementation of this strategy stirs up a cloud of doubts and unanswered questions.

The major issue is to decide how much skill is enough. The complexity of structurally similar algebraic tasks can be measured on a continuum of difficulty. For instance, each of the following expressions can be factored by the same general procedure, but the problems demand very different levels of skill:

$$x^2 + 5x + 6 = (x + 3)(x + 2)$$

$$9x^2 + 12x + 4 = (3x + 2)(3x + 2)$$

$$a^6x^2 + 2\sqrt{5}a^3b^2x + 5b^4 = (a^3x + \sqrt{5}b^2)(a^3x + \sqrt{5}b^2)$$

Pessimists might argue that students are currently achieving only the simplest levels of skill -- implying that no change would result from the proposed reductions in curricular complexity. However, there is a more serious question raised by those who contend that students gain understanding and proficiency only by applying basic skills in more complex settings. The issue has a parallel in debates about the role of multidigit multiplication or division problems in fixing basic arithmetic skills and the understanding of algorithms. Research offers no clear guidance on that long-standing question, much less on the analog in algebra. It is one of the fundamental questions raised by the mechanization of any procedure and merits careful study.

The second family of questions raised by proposals to delete or diminish attention to selected topics in high school algebra concern the roles of algebra in other branches of mathematics. If algebra students do not learn how to multiply binomials like (a + b)(c + d) in early work, will they be stymied when faced with the complex number product (a + bi)(c + di)? If students are not proficient in work with factoring polynomials or combining rational expressions, how will they deal with calculus tasks like

$$\lim_{x \to 3} \frac{x^2 - 5x + 6}{x^2 - 9}$$

or partial fraction expansions? Many of the problems in analytic geometry and trigonometry also require student facility with algebraic forms and manipulations. The discrete mathematics used extensively in computer problem-solving methods also uses algebraic manipulation extensively. Each of these potential prerequisite problems must be analyzed carefully prior to a change in algebra -- a fundamental part of the mathematics curriculum network. It is not, however, defensible to look at the varied uses of algebra elsewhere in mathematics and dismiss possibilities for change. Those other areas will be changing too. The muMath programs can verify trigonometric identities, calculate limits, and perform indefinite integration for which partial fraction methods are commonly used.

A third challenge facing proposals to "simplify" the demands of school algebra is the general concern that the study of mathematics is weakened by simplification. Mathematics teachers often argue that algebra develops habits of precision and accuracy in student reasoning and specification of answers and that it encourages ability in abstract reasoning. The natural inference is that if computers do all the harder problems, many important benefits of such work will be lost to students. Here again, there is little research evidence to support the contentions of "common wisdom" in mathematics teaching. One might argue that in learning to communicate with computers, algebra students will gain very powerful lessons about the need for the precise expression of ideas and, further, that the comparison of results from numerical and symbolic computer solution methods offers a deep insight into the question of accuracy for answers.

The questioning of "weakened standards" in algebra probably also expresses a more general concern for the intellectual demands of schooling. Such concern implies that schools have uniform expectations of all students and, furthermore, that anything hard is good. As a counter to this reasoning, one might ask why agriculture, business, and industry do not reject frequent introductions of new intelligent and powerful equipment, or why nearly everyone has readily accepted hand calculators for arithmetic?

The preceding proposals of topics to be deleted or given reduced attention in high school algebra will certainly provoke vigorous dissent from all corners of the mathematical community. One factor in that dissent is a very reasonable concern that overreliance on the aid of computers will leave students shortchanged in the knowledge of algebraic methods and their uses for solving problems. However, debate over the inclusion or emphasis of specific topics is itself shortsighted in a way that has been typical of each area of human activity to which new technology has been applied. The technology has first been used to execute conventional procedures more swiftly and accurately -- simulating the behavior of human workers. Only later have people seen the potential for exploiting the special strengths of technology to accomplish tasks in entirely new ways.

When mathematics teachers first look at computers as factors in the curriculum, they see potential for a tireless, patient drillmaster. When they first write programs to help the solution of systems of linear equations or linear programs, they expect students to understand fully the algorithm implemented in order to enter data, to choose pivots, and to interpret the solution matrix properly. Watching a demonstration of the muMath SOLVE instruction, they criticize its "black box" appearance, asking instead for a routine that requires student choice of each step in the solution process (a mode which muMath does offer). This approach to technology use misses striking opportunities that appear when fundamental assumptions are challenged. The more radical changes suggested by such analysis fall into two broad categories -- new approaches to sequence and new content themes in the algebra curriculum.

New sequences for algebra topics. Over the past decade, schools have devoted great energy to the specification of carefully sequenced curricula in all subjects areas. The plans very often consist of detailed performance objectives carefully arranged in hierarchies of logical and psychological dependence outlining the optimal path for development of knowledge in the mind of each student. Few subjects seem better suited to this type of analysis than mathematics. Thus, despite evidence in every teacher's experience that students learn and forget incomplete pieces of the whole mathematical fabric, secondary mathematics course sequences and individual topics are analyzed with care appropriate to a building that would collapse upon the removal of a single brick.

The fundamental assumption behind design of curricular sequences in mathematics -- especially algebra -- is the belief that complex ideas and skills must be acquired through a process starting with simple building blocks. For most teachers there is no question that technical skills must be mastered before applications and problem solving can be tackled. The capabilities of current and projected computing technology challenge this assumption and open very different possibilities for curriculum sequence in algebra. With the aid of computers that perform algorithmic manipulations, the conventional order and priority of topics could be inverted. The algebra experience could begin with, and focus on, the processes of expressing and interpreting quantitative relations in symbolic (and graphic) form, with far less attention paid to the techniques of symbol manipulation.

Since the technology that makes such alternative curricula possible has appeared very recently, there are no existence proofs for the efficacy of radical new algebra sequences. What seems possible and worth a try is something like the following approach, illustrated with a conventional topic, quadratic equations:

Stage 1: Where do quadratic equations arise?
- Scientific principles like projectile motion
- Nonlinear revenue, profit, demand, or cost functions
- Fitting rules to curvilinear data

Stage 2: How does one solve an equation like $ax^2 + bx + c = 0$?
- Guess-and-test successive approximation
- By hand to illustrate ideas of solution possibilities
- By graph
- By computer for refined search
- Formal solution by computer
- TK!Solver
- muMath

Stage 3: Formal analysis of solutions to the quadratic.
- Number and type of possible roots
- Relations of coefficients and roots
- Formal manipulations, including factoring and quadratic

This **inverted order** of approach to algebra (a similar sequence could be used for other types of equations) offers several attractive advantages. It begins with problem situations for which algebra is useful, thus offering the best possible motivation. It allows students to get answers to the problem questions quickly, without extended side trips to learn technique. It allows the natural selection of those students with aptitude and interest in formal algebra, since those facets of the subject can now be reasonably delayed. No longer must all students struggle through years of preparation for a promise of applications in the future. Further, students who proceed far into algebra should gain valuable new kinds of insight. Finally, it emphasizes a very powerful, yet simple, equation-solving strategy -- successive approximation. Whereas millions of students now spend long hours mastering complex formal methods, only to forget them soon after the end of instruction, it is unlikely they will forget "guess and test," which, with computing capabilities available, is very efficient. It can even be argued that in working with computers the most important human contribution is to subject machine results to informal tests of reasonableness.

Implicit in forecast changes for the sequencing of algebra topics are important new content themes. Courses that stress computing and applied problem solving would probably place increased stress on conceptual understanding -- the ability to plan and interpret algebraic operations -- with less attention paid to manipulative speed and accuracy. The new algebra course should probably give increased attention to a number of other important ideas.

Proportional reasoning and functions. The most common applications of mathematics in practical and scientific problem solving usually require an understanding of ratio, proportion, and scaling in order to model situations embodying direct and inverse variation. The generalization of simple variation to the concept of function has long played a key unifying role in mathematics and its applications. For more than 60 years, curriculum advisory groups have recommended that an emphasis be placed on the idea of function. However, today's typical secondary school curricula pay little attention to functions until a senior precalculus course. Computers offer tools that make a function-oriented curriculum possible.

Consider contrasting approaches to an appealing topic -- the description of projectile motion. The conventional algebra course focuses on a single question type: Find x, satisfying given conditions. For instance, find x so that

$$-16x^2 + 64x + 80 = 0$$

the time when the projectile reaches ground level. The emphasis in algebra is on the manipulative techniques required to find $x = 5$. Approaching the same situation from a functional point of view, one asks a much richer collection of interesting questions:

If $h(x) = -16x^2 + 64x + 80$ gives the height at time x,

- What is the height for $x = 0$ and other values of x?
- What is the maximum value of h?
- What is the rate of change in h when $x = 1, 2, \ldots$?
- When is h increasing? decreasing?

These important questions have commonly been forestalled until late in student's mathematical experience because the techniques required to calculate answers have also required long, patient instruction and practice. But computer software tools now widely available have changed these boundary conditions. As demonstrated earlier in this chapter, a short computer program will yield an extensive table of x, h(x) values. The inspection of such a table gives practically useful answers to many of the basic questions posed. Computer graphic routines provide powerful visual insight into the same time/height questions. Further, with computer help and curve-fitting ideas explained, it is possible to deal with much more complex (and accurate) models for phenomena like these. We need not limit considerations to low degree polynomials with their obviously unrealistic assumptions like fall occurring in a vacuum. Thus, finally, it seems feasible to implement an algebra curriculum in which the central ideas are functions and graphs.

Integrated algebra, geometry, and analysis. Conventional mathematics courses provide students with learning tasks and application problems conveniently, yet artificially, sorted into carefully sequenced compartments and hierarchies. The special ability of computers to produce dynamic graphic displays of quantitative relations enriches the study and meaning of algebraic ideas. It also argues for coordinated consideration of topics from algebra, geometry, and analysis, and an effective attack on realistic problems that involve questions from all three topic areas simultaneously. One of the strongest barriers to integrating these subjects -- the need to develop prerequisite technical machinery -- will be greatly diminished by technology. This effect can also facilitate closer coordination of mathematics and science instruction.

Approximate computation. One of the marvelous benefits of access to calculators or computers is the effortless performance of tedious arithmetic. But intelligent use of this power requires awareness of risks. For instance, given measurements of a cylinder that are accurate to one decimal place -- radius = 3.2 cm and height = 6.7 cm -- the calculator will suggest volume = 215.5383887 cm^3, with implied accuracy far beyond reason. Further, in a long string of arithmetic operations, truncation and round-off errors can be very serious. Students being prepared for life in a calculator/computer age must certainly develop critical awareness of issues in approximate computation as it is used in many computer procedures.

Algorithm analysis. To enlist the aid of computers in solving algebra problems, one must invariably design or use an algorithm of some complexity. Understanding computers and their capabilities/applications in mathematical problems requires some understanding of algorithms, the conditions for their use, and the types of results that can be produced. At a higher level, there is reason to expect that student design or analysis of algorithms for specific algebraic processes will yield a deep insight into the structure of those processes. At yet another level, some students will profit from the comparison of algorithms that are designed for a common purpose. Questions of efficiency, ease of computer implementation, and provable correctness are important considerations in many situations.

Matrices and linear algebra. The information-processing capabilities of modern computers make large data bases and multivariate quantitative models feasible and increasingly common. Many of the mathematical ideas used in this work are part of linear algebra and matrix theory. At an elementary level, students can probably profit from introduction to linear programming, matrices, and vectors. The importance of linear algebra throughout more advanced mathematics has grown immensely during the past several decades, offering opportunities to extend and apply the basic ideas in many directions.

Finite methods. Despite its impressive ability to deal with complexity by very rapid information processing, a digital computer is fundamentally a finite machine that operates on discrete bits of information in discrete steps. The design of the machines and their program software draws heavily on algebraic structural ideas from set theory, Boolean algebra, logic, groups, rings, fields, and lattices. Many important algorithms are basically sequential processes, making mathematical induction a very important tool for verifying results. It seems likely that the introduction of these concepts should begin in secondary school algebra.

None of the topics discussed above are entirely new themes for secondary school algebra. However, their emergence to center stage is a consequence of fundamental changes in the role of human intelligence in problem-solving activity. As procedural operations are increasingly mechanized, there remains an important task of conceptualization and planning. Problems must still be identified and cast in mathematical form; the proper analyses must be structured and the results of computer-assisted calculations must be properly tested and interpreted. To perform this fundamental role, individuals must have a sound understanding of the scope and structure of available mathematical methods. While this understanding has always been important, it seems fair to say that high school algebra instruction has been so preoccupied with training students in procedural skills that there was precious little time available for the broader conceptual goals. Although some algebra teachers might see muMath or TK!Solver as threats to their livelihood, the effect of building a course to account for such technological aids is, instead, a revelation of the very important instructional goals that have been neglected in the past. There remains a great deal of algebra to be taught, but it is algebra of a different character than that of most high school courses.

A research-and-development agenda for high school algebra

In thinking about the implications of computing for high school algebra curricula, the easiest part of the task is assessing the technological possibilities and prospects. It seems clear that in the very near future, the numerical and symbolic manipulative procedures of elementary algebra will be available in easy-to-use software on machines of nearly hand-held convenience. The imaginable curricular responses to this changing environment for calculation in algebra range from a modest de-emphasis of traditional skill development to a major restructuring of the entire secondary mathematics curriculum. Algebra courses could remain substantially as they are, with some of the more complex computations left to computers; or algebraic concepts could be woven together with geometry, calculus, and applications to science in a program where the emphasis is placed on the modeling of situations and interpretation of the calculations accomplished almost entirely by computer.

In the short run, decisions about possible curricular alternatives will be based on the intuitive judgements of experienced teachers and mathematicians. Change will probably be very modest. However, an intelligent assessment of the opportunities available from more radical alternatives will require the following analysis, research, and curriculum development studies:

1. *Analysis of the algebraic skills and understanding used in applications to assess the possible effects of curricula that do less skill development or prepare students with skills at a later than usual time*. The analysis presented in this chapter has stressed the impact of computers that solve equations or graph functions. However, there are countless places where a facility with algebraic manipulation might be a critical prerequisite to theoretical understanding. For instance, combinatorial problems involving

$$\binom{N}{K}$$

are frequently aided in crucial ways by the algebraic rearrangement of

$$\frac{n!}{(n-k)!\,k!}$$

2. *Basic research to test the hypothesis that skills must be acquired before conceptual understanding or problem solving can proceed.* Similar basic studies should be done on the learning of fundamental algebraic concepts like variable, functions, and proportion.

Computer graphics and symbol manipulation utilities must be studied to determine the ways that students can learn to manipulate those tools intelligently. For instance, a function-graphing program is helpful only if the users can effectively scale their problem for entry into the machine or can correctly interpret the distortive effects of an automatic-scaling program. Although muMath offers a powerful aid in the manipulation of algebraic expressions, we need studies that will determine effective ways to make students aware of the meaning and usefulness of equivalent mathematical forms for expressions.

The discussions of this chapter have assumed that students can deal comfortably with variables. There is striking evidence from recent research (Lochhead 1983) suggesting that this conceptual understanding comes very slowly. Computer experience might help this development, but careful analysis and research are required in this critical area.

3. *Development and field testing of model curricula embodying the following themes*:

a) Careful treatment of concepts and problem solving with variables, equations, and inequalities prior to skill training -- using computers to produce "answers" to technical questions
b) Intelligent use of successive approximation by graph or tables of function values to find roots of equations (There is evidence that students, if not carefully taught, can begin using the approximation methods as mechanically as symbol manipulation methods like factoring.)
c) Functions and graphs as the central ideas of algebra
d) Integration of ideas from algebra, geometry, and calculus in a way that makes them accessible to younger than normal students
e) Attention to matrix ideas
f) Algorithmic approaches to basic algebra topics
g) Creative approaches to algebraic structure

In each of these seven individual explorations of possibilities, there should be an attempt to show the best contribution of computing imaginable, not limited by immediate practical concerns of getting the technology into schools on an everyday basis.

THE IMPACT OF COMPUTING TECHNOLOGY ON SCHOOL MATHEMATICS

REPORT OF A MARCH 1984 NCTM CONFERENCE

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One of the critical problems facing mathematics education today is the need for curricula and instructional methods to respond to the influence that computing technology is having on mathematics and its teaching. Numerous conferences, reports, and projects have focused on different aspects of the effect of emerging technology on mathematics curricula and instruction. For example, the Conference Board of the Mathematical Sciences produced a set of guidelines that identified fundamental topics in K-12 mathematics (CBMS 1983), and an NSF-sponsored conference at the University of Maryland resulted in a document that provided insight into the effect of the computer on subjects in the traditional secondary mathematics curriculum (Fey 1984).

NCTM has made many efforts to provide leadership as decisions about the impact of computing technology on mathematics education are made. In 1981 its Board of Directors established the Technology Advisory Committee, which has subsequently engaged in several projects and activities that serve members in the area of technology and which advises the Board on matters relating to technology and mathematics education. NCTM sponsors a continuing series of seminars for K-12 mathematics teachers on the uses of computers in mathematics instruction and has for a long time devoted program slots at regional and national meetings to issues associated with the impact of technology on mathematics education. The publications of NCTM, including the journals and the 1984 Yearbook, reflect the continuing concern of the organization with this issue.

In an effort to continue its leadership role, NCTM and the Center for Mathematics Education of the University of Maryland, with financial support provided by the National Science Foundation, sponsored a conference at NCTM headquarters during March 1984 to consider "The Impact of Computing on School Mathematics." Participants represented a number of interested constituencies: government funding agencies, commercial publishers of mathematics materials, the standardized testing industry, mathematics teacher educators, mathematicians, computer scientists, elementary, middle, and secondary mathematics teachers, and district-and state-level mathematics supervisors. Participants were asked to respond to a series of questions related to the impact of computing technology on the mathematics curriculum, mathematics instruction, and mathematics teacher education, and to formulated general recommendations in each of these areas. The conference produced the recommendations herein -- each gaining broad, if not unanimous, support.

RECOMMENDATIONS ON CURRICULUM, INSTRUCTION, AND TEACHER EDUCATION

Prologue

Applications of calculators, computers, and other electronic information technology are reshaping the fundamental methods of doing and teaching mathematics. When used as tools for arithmetic and for the analysis of graphic or symbolic data, calculators and computers offer powerful new approaches to familiar problems and access to entirely new branches of mathematics. Applications of these same capabilities to instruction are bringing major changes to mathematics classrooms and the roles of mathematics teachers.

The major influence of technology on mathematics education is its potential to shift the focus of instruction from an emphasis on manipulative skills to an emphasis on developing concepts, relationships, structures, and problem-solving skills. Traditional precollege mathematics curricula have stressed the development of a variety of mechanical procedures, including the computational algorithms of arithmetic and the transformation of symbolic expressions in algebra, trigonometry, and analysis. The use of calculators and computers as standard tools in quantitative problem-solving situations, however, has diminished the value of human proficiency in the execution of such procedures. Much of the instructional time currently devoted to acquiring proficiency with paper-and-pencil algorithms should be reallocated to support a range of new or previously neglected topics that have a valid place in the K-12 mathematics curriculum. Moreover, teacher education programs must be modified to reflect these changes in school mathematics content and to model the delivery of instruction through appropriate applications of technology.

The proposals that follow are intended as guidelines for selecting the content of precollege mathematics curricula, for teaching that content in a manner that takes advantage of emerging technology, and for designing teacher education programs that recognize the changing curricular patterns and instructional roles for teachers. The proposals are based on five fundamental assumptions:

1. Coordinated change can take place simultaneously at all levels of mathematics instruction.
2. All students and teachers will have access to calculators and computers for the study of mathematics, in the classroom and at home.
3. All students will experience appropriate application of computers in the study of each school discipline.
4. State/provincial, district, and local mathematics curriculum guidelines and criteria for mathematics textbook adoption will be rewritten to reflect the changing priorities of school mathematics.
5. The publishers of standardized texts and instructional materials will
   - (a) immediately begin developing products that are consistent with the changing objectives of precollege mathematics;
   - (b) continue support for that development on a schedule that facilitates the implementation of proposed curricular changes.

TECHNOLOGY AND THE MATHEMATICS CURRICULUM

Today, the computational skills of arithmetic, algebra, geometry, trigonometry, and calculus dominate the K-12 mathematics curriculum. The content and sequences of courses are planned carefully so that students acquire intricate hierarchies of prerequisite skills for each major computational algorithm. Although these well-known mathematical procedures originated as essential aids to efficient problem solving, most of the algorithms of school mathematics have now been programmed for rapid execution by calculators and computers.

To do arithmetic today, mental operations are best for obtaining quick approximations; calculators are the tools of choice for one-time computations; and computers are most appropriate for repetitive calculations. In algebra, trigonometry, and calculus, computers can execute the numerical and symbolic manipulative procedures that students spend countless hours mastering.

As a consequence of this changing environment for mathematical work, the curriculum in grades K-12 needs careful reassessment and revision. Classroom teachers, mathematics supervisors, members of state departments/provincial ministries of education, authors and publishers of textbooks, developers of standardized tests, and other curriculum developers must consider the following recommendations and the questions they raise.

Elementary School Level

The elementary school mathematics curriculum has traditionally focused on developing students' skills in computing with whole numbers, fractions, decimals, and percents. Since computers and calculators can perform such operations more quickly and accurately than can usually be done otherwise, the traditional goals of elementary school mathematics must be reexamined and the predominance of computation-related objectives must be reassessed. Curriculum developers are urged to consider the following recommendations that suggest a broadened view of mathematics appropriate for grades K-4.

- Calculators should routinely be available to students in all activities associated with mathematics learning, including testing. Students should be taught to distinguish situations in which calculators are appropriate aids to computation from situations in which mental operations or paper-and-pencil computations are more appropriate.

- Emphasis should continue to be placed on students' knowledge of basic facts required for proficient mental arithmetic and estimation. However, significant portions of elementary curricula devoted to algorithms for multiple-digit calculations can be eliminated.

- Instruction must shift to emphasize the meaning of arithmetic operations. Such understanding is essential for problem solving.

- Experience with physical manipulatives and other concrete representations of concepts must continue to be an important phase of learning mathematical ideas. Because of the increased instructional emphasis on meaning and understanding, this activity must not be overlooked as the curriculum evolves to take advantage of computers and calculators for instruction.

- Because computers and calculators can be used effectively in teaching mathematical concepts, no a priori assumptions should be made about the appropriateness of any given mathematical topic for elementary students. For instance, decimals, negative numbers, and scientific notation appear naturally when using calculators and can be taught as they arise. Computers facilitate an early introduction to geometric concepts such as transformations, congruence, and vectors; statistical concepts such as randomness; and algebraic concepts such as variable and function.

- Preprogramming activities and simple computer programming in Logo or BASIC can be done by students as early as the kindergarten level to convey both mathematical and computer concepts. Computer literacy should come as a natural by-product of such experiences rather than as a special addition to the elementary school curriculum.

Middle School Level

The mathematics curriculum for the middle school (grades 5-8) must take into account incoming students' knowledge of new topics such as computing, their understanding of topics formerly reserved for the middle grades, and their more limited skills in topics such as arithmetic algorithms. In addition to building on the changes proposed for the elementary grades, curriculum developers for the middle grades should consider the following specific recommendations.

- Mathematics in the middle grades should emphasize the development of "number sense" -- the intuitive feeling for the relative sizes of numbers that is essential in skillful estimation, approximation, mental arithmetic, and the interpretation of results for reasonableness.

- Some portion of instructional time should be given to the study of discrete mathematics, including counting, graph theory, probability, and logic, which is important and appropriate for the middle grades.

- Calculators and computers can be used to teach iterative procedures for solving significant problems before traditional formal methods are presented. Such experiences should be part of the middle school mathematics curriculum.

- An introduction to statistics should include extensive gathering, organization, and presentation of data. Important concepts can be developed in the context of real data sets whose manipulation and examination is aided by computer analysis and graphing software.

- Middle school mathematics programs should take advantage of the visual display capabilities of computer graphics that support and underscore the importance of informal geometry objectives. Transformations, mensuration formulas, and spatial visualization can be vividly illustrated by using computer graphics.

- Increased emphasis should be placed on such nontraditional methods of problem solving as organized lists, guess and check, geometrical sketches, and successive approximations, all of which are made feasible by calculators and computers.

- Computer programming experiences that introduce the concepts of variable and function should be provided. These experiences should help prepare students for the study of algebra.

- By the end of grade 6, students should be able to write simple computer programs that require looping and branching concepts. The emphasis in such programming activities should be on problems that convey significant mathematical ideas.

Senior High School Level

Developers of senior high school mathematics curricula must consider both the changing preparation of their entering students and the changing college and work environments their graduates will enter. The following recommendations are suggested as guidelines for the curricular evolution that must occur if high school mathematics programs are to reflect appropriately the influence of technology on mathematics and its teaching.

- The selection and sequencing of high school mathematics for college-bound students should no longer be governed solely by preparation for calculus. The most important mathematics for many students will consist of topics from discrete mathematics and statistics. High school programs must reflect these goals in their content and priorities.

- Computing is changing calculus and its traditional prerequisite subjects. Computer symbolic systems, graphics, and numerical analysis software make student mastery of manipulative procedures less important and, at the same time, offer dynamic tools for the illustration of fundamental concepts and processes. Such changes should be considered as the influence of calculus on high school mathematics is assessed.

- The content priorities and approaches to topics in high school geometry should be reconsidered in light of computer graphics and their applications. The geometry of three-dimensional space, trigonometry, vectors, coordinates, and transformations are all made more accessible with computer assistance through visual displays and complex calculations.

- The skill objectives of algebra must be reassessed to identify those procedures more easily done by computer (e.g., combination of expressions or solution of equations) or calculator (e.g., values of trigonometric functions, logarithms, or exponentials). The properties of elementary functions are still important for quantitative relationships, but proficiency in many familiar computational processes is of little value.

- In many topics of high school mathematics, computers and calculators can be used to discover and test principles and methods. For example, concepts and theorems can be illustrated numerically and graphically to develop sound understanding before formal proof is attempted.

- For high school students with limited ability or interest in mathematics, technology offers an opportunity to enrich curricula with realistic problem-solving situations without insisting on a mastery of skill prerequisites. For example, these students can concentrate on the skills needed to collect, organize, and interpret mathematical information, skills appropriate for estimation and approximation, problem-solving strategies, data analysis methods, and reasoned evaluation of results.

TECHNOLOGY AND MATHEMATICS INSTRUCTION

The impressive capabilities of emerging technologies promise major changes in the organization of mathematics instruction and in the roles of students and teachers. Computers offer a dynamic electronic chalkboard for the demonstration of mathematical ideas. As laboratory tools, they assist in the exploration and discovery of concepts, the practice of skills, applied problem solving, and instruction by simulation. Computer-based evaluation and information management provide further opportunities for change in traditional teaching/learning patterns.

Although there may be risks associated with changing instructional patterns and teachers' and students' roles, the potential for improved instruction in mathematics makes the search for ways to reduce those risks worthwhile. If teachers and students are to exploit the potential of technology to support instruction, they must become adept at the new roles described in the recommendations below.

One of the most immediate consequences of the integration of technology into mathematics instruction is the increased need for teachers to make informed decisions about questions that relate to certain aspects of the mathematics curriculum. The following recommendations focus on these issues.

- Teachers must be able to make informed curricular decisions about the appropriate place and strategy for using technology to enhance instruction.

- Teachers must learn how dynamic visual displays made possible by computers can aid transition from concrete experience to abstract mathematical ideas.

- Teachers must become adept at interpreting and elaborating computer-based evaluation of student learning and in using information management systems that organize curriculum options and assessment data.

New roles for classroom teachers and students are also made possible by technological enhancements of mathematics instruction. Among these roles are the following:

- Teachers must become effective catalysts for student-directed learning. They must be able to pose stimulating problems and to probe student understanding with questions that begin "What would happen if. . .?"

- Teachers must serve as learning models in attacking mathematical questions. They must be comfortable assisting students in learning situations in which the topic being studied or the resource employed is unfamiliar. Teachers must be prepared to say, "I don't know yet," while they join students in exploration.

- Teachers must become facilitators of cooperative learning as students engage in realistic learning projects that computers make attractive. Teachers and students must emulate real problem solvers as they deal with problems of complexity, accuracy, and precision that occur in the collection and analysis of real data.

- For students, the greatest promise and challenge of technology in mathematics learning is the move toward more self-directed and self-monitored learning. Students must become adept at using computer-based instructional materials, mathematical tool software, and personal programming skills to develop and practice the use of mathematical concepts, principles, and problem-solving processes.

- Student-directed learning suggests that students may become dispersed throughout the learning environment. Teachers must know how to maintain effective communication with and among learners and must recognize that individualized technology-enhanced learning is not synonymous with independent study.

The fundamental theme that underlies recommended changes in patterns of mathematics instruction and in the roles of teachers and students is the emergence of a new relationship among teachers, students, and the subject matter. The presence of computers and calculators in demonstration, practice, problem solving, and evaluation creates a new classroom dynamic in which teachers and students are natural partners in the search for an understanding of mathematical ideas and a solution of mathematical problems.

TECHNOLOGY AND MATHEMATICS TEACHER EDUCATION

The recommendations in the previous sections of this report suggest a new look to mathematics classrooms, with concepts and problem solving the focus of curricula and teachers joining their students as active partners in learning. If these changes are to occur, classroom teachers must be the primary agents of change. Consequently, preservice and in-service mathematics teacher education programs must be restructured to prepare teachers for their new roles.

Computer education for teachers of mathematics requires understanding and skill in three areas: (1) the uses of computers and calculators as problem-solving tools in mathematics; (2) the uses of computers for the presentation, evaluation, and management of instruction; and (3) the concepts of computer literacy that contribute to, or depend on, the knowledge of mathematics. The breadth and depth of appropriate computer education will vary with the teacher's grade level and subject specialization. The following recommendations provide guidelines to the content and form of preservice and in-service experiences suitable for elementary, middle, and senior high school mathematics teachers.

Mathematics content and methods courses in teacher education programs must be examined and restructured to give more attention to priority content areas and to make calculator and computer use an integral part of all such courses. In particular, the following recommendations apply:

- Students preparing to teach at the elementary level must complete the mathematics requirements outlined in the *Guidelines for the Preparation of Teachers of Mathematics* (NCTM 1981), with special emphasis on estimation, approximation, mental arithmetic, data organization and analysis, informal geometry (using a variety of approaches to the subject that reflect its visual nature such as transformations, vectors, and coordinates), probability concepts, and measurement concepts.

- Computer literacy and programming concepts needed by elementary teachers should be acquired through experience in the mathematics content and methods courses. Consequently, teachers preparing to teach at this level need not be required to take a formal computer science course, although a course focusing on computer applications in education is recommended.

- Students preparing to teach at the middle school level should also complete the mathematical requirements outlined in the NCTM *Guidelines* for this level, with special attention to the priority topics recommended for elementary teachers and experience with more advanced topics from algebra, analysis, statistics, and discrete mathematics.

- Middle school mathematics teachers should complete a course on computer applications in education and a computer science course that focuses on problem solving and, more specifically, on the nature of algorithmic thinking and the computer implementation of problem solutions.

- Students preparing to teach mathematics at the secondary level should complete the mathematics major outlined in the NCTM *Guidelines* and coursework in discrete mathematics, probability and statistics (including exploratory data analysis), and numerical analysis. All topics must be taught in ways that demonstrate appropriate applications of computing to mathematics.

- In addition to the computing courses recommended for middle school teachers, secondary mathematics teachers should complete study that provides further experience with structured programming, algorithmic thinking, mathematical modeling, and other mathematics fundamental to computer science.

To provide teachers of mathematics with the knowledge and skills needed to use computers and other technology effectively for instruction, programs of preservice and in-service education must include the following components:

- Level 1 (awareness). Through the use of computers, calculators, and other technology as an integral part of the delivery of instruction in mathematics, teachers must be exposed to a variety of applications that enhance their understanding of the potential of these technologies. They must experience a range of hands-on activities and explorations and see demonstrations of appropriate uses of technology in classrooms.

- Level 2 (interaction with prepared software). Teachers at this level must be given training in the selection and use of appropriate software to enhance instruction in mathematics, and information should be given to them about sources of mathematics-related software. They must develop, deliver, and evaluate lessons and units that integrate existing software into mathematics instruction.

- Level 3 (interaction with programming). Teachers should be given the opportunity to engage in programming-related activities such as tracing, debugging, or modifying existing programs, all of which can enhance mathematics learning. Such experiences should focus on how programming ideas can be used to teach mathematical concepts, not on developing the teacher's personal programming skills.

The most important point in these recommendations for change in mathematics teacher education is the requirement that preservice and in-service programs must model the desired changes. Teachers must *experience* mathematics content and methods courses that emphasize priority topics and that present those topics using a variety of techniques that fully integrate computers, calculators, and other information-processing technologies. The realization of this goal will require commitment and cooperation among mathematics and teacher education faculties. Institutions must commit needed resources for equipment and must support faculty study time.

- Every institution should identify a computer resource teacher who can serve as a technical advisor for all teachers and a mathematics/computer resource teacher who can provide leadership in helping teachers make appropriate use of computing devices in mathematics instruction. Institutional support for training such individuals will be needed.

- Institutions must provide ongoing support mechanisms. Administrators must be educated about proposed changes in mathematics content and the delivery of instruction and must be supportive of changes. Initiative and achievement must be recognized.
- Colleges and universities should work with local schools and districts to devise creative models for in-service programs to upgrade teachers' backgrounds and ways to provide support for teachers as changes are implemented. Such programs must build in mechanisms to inform teachers at upper levels about curricular and instructional changes at lower levels and vice versa.
- Professional organizations such as NCTM must offer training workshops to prepare teacher educators for leadership roles in effecting change. Funding agencies must offer support for retraining activities.

Well-educated, committed teachers will be the key to the successful implementation of curricular and instructional improvements. The computer education of preservice and in-service teachers represents a critical investment necessary for change to occur.

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4.8
SESSION 8: PROJECT REPORTS AND CLOSURE

4.8.1 Narrative Overview

The participants were told at the beginning of the inservice that they would be required to do an individual or group presentation during the last session. The main topics they could choose from were:

1. What can you as an individual do to help integrate computers into the math curriculum that you help provide? Include detailed examples of what you are doing and/or intend to do.
2. What are your math department's future plans for integrating computers into the curriculum? Include a detailed discussion of current levels of implementation, the planning that has occurred, and what your department expects to accomplish in the next year or so.

In both cases participants were told not to focus on a lack of software and hardware. That is, the focus was to be placed on what could be done with facilities that were available or which were apt to be available. Both topics are a type of long-range planning. Vivian Johnson's Ph.D. dissertation, which was an evaluation of some of the long term effects of the NSF inservices, indicated that schools that had done long-range planning tended to make greater progress than those lacking such plans.

When the NSF grant project was begun in 1985, the intent was to require that there be a school administrator participant from each school having teacher participants. While this objective was achieved during the first year of inservices, we were less successful during the second and third year of the project. Thus, for example, during the second year we were replicating the math inservice, and many of the ideas in this Notebook were being tried out for a second time. But we were unable to get a strong commitment from the school administrators in the schools that wanted to participate. We instead got a commitment that the administrators would attend the last session and at least one other session.

It is important for inservice providers to be aware that often there is substantial difference between what we "know" are the right things to do to help increase the effectiveness of an inservice, and what we are actually able to do. We decided it was better to have a low level of administrator participation, and have a goodly number of teacher participants, than to have only very few teacher participants. (That is, if we had attempted to stick to an absolute requirement of full administrator participation, many teachers would not have been able to participate because their school administrators were unwilling to make the necessary commitment to participate.)

One major purpose of this last session is to get participants to verbally commit themselves to a plan of action for the future in their particular department or school. It is felt that participants who tell their peers about things they intend to do are more apt to do them. The last session also is designed to bring a sense of closure to the inservice series. Thus, time should be provided for a final summary, discussion, follow-up opportunities, etc.

Finally, time needs to be provided for a short evaluation session. More formative and summative evaluation data is to be gathered.

There are many other possible topics for projects that participants might work on for a number of weeks and then present at a final session. Many inservices have participants work on curriculum development projects centered around a particular piece of software. For example, the participant might pick a graphics program and develop several lesson plans making use of the software. These lesson plans might be tried out in the classroom. Then the final project would be a detailed writeup of the lesson plans and a discussion of how well they worked in the classroom. Such lesson plans are shared among the participants.

Educational change is a slow and difficult process. Participants in the NSF inservices tended to be well qualified, highly motivated teachers. Some had substantial previous computer inservice training while others had none. Each teacher seems to have his or her own threshold of inservice training and computer experience that is needed before feeling comfortable in beginning to make significant use of computers in the classroom. The final session should be designed to encourage participants to continue to build on the knowledge and experience gained during the inservice. One measure of success of the inservice is the level of immediate and continued computer application in the classroom. But a second measure is whether participants continue to learn and grow in the computer education field. Even if they only make the most mundane and minimal use of computers during and immediately after the inservice, have they acquired foundational knowledge, skills, and positive attitudes that lead to continued growth? If the answer is yes, the inservice should be considered to be quite successful.

INSTRUMENTS AND EVALUATION

5.1

Evaluation Overview

Rational for Evaluating Inservice Programs

The planned outcome of many inservice programs is a set of changes in attitude or behavior. While formal evaluation provides staff developers with a useful tool in planning, designing, developing, and implementing of staff inservice, "systematic evaluation of inservice programs is the exception rather than the rule" (Gall & Renchler, 1985, p. 28.). The literature survey conducted by Vivian Johnson (1988) for her Ph.D. dissertation indicated that very few inservice projects are adequately evaluated either while they are being conducted or after they have been conducted. That is, very few inservice facilitators gather data that could be used to judge the effectiveness of their work.

There is a substantial literature on effective inservice practices. In addition to Johnson (1988), a good starting point for the novice student of this field is Wade's (1984-85) meta-analysis of 91 inservice studies. There is a very substantial bibliography in Joyce and Showers (1988). A number of effective practices identified by Stecher and R. Solorzano (1987) are listed in Table 1 given on the next page.

Evaluation studies provide staff development personal with a mechanism for judging the effectiveness of a program. The evaluation processes is divided into two components: formative and summative. A key point to remember is that the development of formative and summative evaluation plans should always occur in conjunction with the planning, design and development of inservice programs.

Formative evaluation concentrates on measuring the immediate success of the program. It begins with a needs assessment. Then as the project continues, it provides feedback for the improvement and development of the ongoing activities. Goals of a formative evaluation include:

1. Developing a permanent record of conditions prior to inservice. (This use also needed for summative evaluation, since it provides a baseline for measuring change.)

2. Determining staff development required for improvement of the school, curriculum, etc.

3. Ensuring the inservice program is implemented as effectively as possible.

4. Identifying unanticipated outcomes.

Of the objectives listed, developing a record of pre inservice conditions is typically eliminated from evaluation plans. This occurs because plans for formative evaluation are neglected until inservice is about to be implemented or is in progress. But without a record describing the pre inservice conditions, it is difficult to determine the type or degree of change that occurs during and following an inservice. This impacts judging the overall effectiveness of a program (summative evaluation), especially when the expected outcomes of an inservice are changes in participant attitudes, behaviors or values.

While formative evaluation is valuable, it provides little insight about the factors that affect institutionalization -- that is, long term acceptance and implementation -- of a change (Fullan, 1982). To determine the long term changes that are maintained following inservice requires summative evaluation. Summative evaluation is also used for accountability, certification, selection or continuation of an established program. It concentrates on measuring the **residual effect** of the program over time (6-12 months or more after the project has ended). Unfortunately, summative evaluation is typically neglected.

Table 1: Effective Computer Inservice Practices

1. Extensive practice with computers.
2. Comfortable and relaxed atmosphere.
3. Appropriate balance between lecture and guided practice.
4. Individual attention.
5. Knowledgeable trainers.
6. Detailed curriculum guides and lesson plans.
7. Clear and relevant objectives.
8. Lesson-related materials and handouts.
9. Inservice lessons linked to instruction.
10. Peer interaction.
11. Voluntary participation.
12. Strategies for teaching heterogeneous classes.

The content of this table is from "Characteristics of effective computer in-service programs." by B.M. Stecher and R. Solorzano, 1987, Pasadena, CA: Educational Testing Service. Copyright 1987 by Educational Testing Service.

Why should you interested in the residual effect? After all, formative evaluation can be designed to measure specific content, skills, or instructional strategies learned by participants during the inservice. But unfortunately, research indicates that knowledge, behaviors, and skills acquired during inservice are seldom transferred to classroom situations. The problem is that without examining the residual effect over time (longitudinal formative or summative) you are unable to determine the overall effectiveness of your inservice program.

A major goal in summative evaluation is to produce accurate descriptions of the program along with measures of its effects (i.e., changes in participant attitude or behavior). These descriptions are valuable for a number of reasons. Typically the program description includes estimations of program cost and helps decision makers determine if the program is worth continuing based on its costs. Program description can also serve as planning documents for people wanting to duplicate the program or adapt it to another setting. Program descriptions also document where you started from, your current state, and where you want to or plan to go. Including descriptions of where you plan to go ties summative evaluation to the first stage of formative evaluation, the needs assessment process.

A final and neglected use of evaluation is for improving recycling of inservice programs. Many inservice providers present their inservices several times per year over a period of years. Keeping track of what presentations go well, what software is useful and the needs of those in the workshop make it easier to improve the next cycle.

Stecher and Solorzano (1987) identify two problems that result from the lack of evaluation research. One, without evaluation research it becomes difficult to judge the relative merits of inservice programs (summative evaluation). Two, without evaluation research, developers have little data to guide them in developing new programs and improving existing ones (formative evaluation).

Planning for evaluation encourages developers to operationalize the goals, objectives, and outcomes of an inservice program. The process of operationalizing encourages developers to divide the change into smaller pieces thus avoiding the pitfall of trying to accomplish a complex change in one step. Evaluation is a constant reminder that change is difficult, complex, and takes a long time.

Current State of Computer Inservice Evaluation

A review of the literature indicated the majority of computer related inservice is not evaluated. When evaluation does occur, it is usually on a small scale and is "one shot," taking place during or within several days of the inservice. The most frequent evaluation goals are determining modifications required for program improvement, making quantitative judgments of whether inservice occurred, and validating that funds were spent on the development and/or initiation of the proposed program or course.

The two most frequently used criteria for measuring the quality of an inservice program are:

1. Changes in participant attitude toward computers.

2. Changes in participant computer literacy or knowledge/skills about particular aspects of using computers.

The selection of these criteria is based on the notion that as participants develop a higher level of computer literacy and knowledge/skills, and positive attitudes toward computers, they will increase their classroom use of computers. *The limited research does not support this notion*! This is a very important point. An inservice can be quite effective in increasing teacher knowledge and skills in the computer field, and have little impact on the teacher's students.

Studies by Vockell & Rivers, 1979, Mitchell, 1986, and Van Walleghem, 1986, suggest that positive attitude toward computers and computer literacy does not have much to do with classroom use of computers. The longitudinal follow-up completed by Vockell and Rivers (1979) indicated that participants completing an introductory computer course subsequently tended not to use computers in their classrooms. Subjects attributed their non use of computers to lack of access rather than a lack of knowledge on how to use them.

Two studies addressed the relationship between changes in teachers' willingness to use computers following inservice and actual classroom use of computers (Mitchell, 1986; Van Walleghem, 1986). These studies indicated that while teacher willingness to use computers increased following inservice, this willingness did not correlate well with actual computer use in the classroom.

Planning to evaluate a computer related inservice

The evaluation of a computer related inservice should be designed to measure the extent that inservice objectives were achieved, identify problems associated with implementing the inservice objectives in the classroom, and measure the long term effect of inservice objectives on student achievement. The evaluation plan should contain two phases, formative and summative, with approximately equal amount of time and effort allocated to each.

Summative evaluation should focus on:

1. Participant knowledge about computers. (Is there a change that can be attributed to the inservice?)

2. Participant attitude toward computers. (Is there a change that can be attributed to the inservice?)

3. Participant instructional and professional use of computers. (Is there a change that can be attributed to the inservice?)

4. Changes in the instructional use of computers by the students of the inservice participant. (Is there a change that can be attributed to the inservice?)

Pre and post questionnaires are effective instruments in measuring changes in participant knowledge and attitude, but remember that increased willingness to use computers does not correlate well with actual computer use in the classroom. If the goal of your inservice is to increase classroom use of computers, your evaluation plan must use additional criteria besides changes in participant knowledge and attitude.

Longitudinal evaluation is the only way to determine if sustained changes in classroom use of computers have occurred following inservice. The evaluation should use of a multi method approach, including both quantitative and qualitative measures. The multi method approach helps expose the numerous factors (access to computers, lack of administrative support, teachers not seeing a value in the innovation, etc.) that inhibit or prevent teachers willing to use computers from actually doing so. Measuring changes in classroom use of computers requires base line data on instructional use of computer use prior to the inservice. Changes in computer use that occur during formative evaluation are insufficient to judge the extent of computer implementation in the classroom. It is necessary to use longitudinal, summative evaluation techniques to see if gains made during an inservice program are sustained.

Summative evaluation also serves other purposes. Plans for longitudinal evaluation are evidence of an institution's long term commitment to implementation of the innovation (it simply is not going to fade away). Identification of factors that impact on the residual effect of inservice can facilitate making changes in the culture and organization of the school necessary to maintain the innovation. Fullan and Pomfret (1977) believe the main problem in implementing curriculum innovations is "that curriculum change usually necessitates certain organizational changes, particularly changes in roles and role relationships of those organizational members most directly involved in putting the innovation into practice (p. 337). ... Often the organizational (role relationship) change aspects of curriculum projects are left implicit in the plans (p. 337)." Longitudinal evaluation makes explicit the organizational and cultural changes that must occur for computers to become an everyday instructional tool. Only when these changes are made explicit can they be addressed in an overall plan for staff development.

Selection of an evaluator

In an ideal situation the use of an outside evaluator to assist in the planning, design, and development of an inservice program is highly recommend. This is especially important if the inservice developers have little experience with evaluation and/or if the inservice is to be presented more than once. An evaluation expert can anticipate generic problems associated with the evaluation process and help train inservice personal in the development of an evaluation plan.

An unfortunate reality is that many inservice projects may not have the resources to obtain the services of an external evaluator. This places the evaluation component in the hands of inservice developers. If inservice personal are unfamiliar with evaluation process, they should solicit as much help as they can from experienced evaluators. It is recommended that the draft evaluation plan be submitted to an external evaluator for review and comment, even if the external evaluator cannot participate in the development and implementation process. No matter who ends up planning and conducting the evaluation, the process should occur in conjunction with the initial planning stages of the inservice.

Role of local evaluator

The primary role of the local evaluator is to gain consensus on the decision to evaluate plan and implement the evaluation. When planning the evaluation, it is necessary to gain administrative and participant support for the process. Typically this requires convincing people of the value of evaluation and dispelling its negative image. A large body of research supports the need for continuous evaluation of any change effort (the change process, models of effective staff development, and innovation and implementation attempts).

Gaining administrative support is especially helpful, particularly when additional resources are required to conduct the evaluation. Participant support is critical and cannot be taken for granted. Prior to the inservice -- that is, during the needs assessment interaction with potential participants -- discuss the value of evaluation in helping to judge the reasonableness of inservice objectives, in assessing reasonable timelines for integrating computers in the classroom, for assessing the extent of resources necessary for this change to occur, and for helping administrators keep in touch with the actual realities of a classroom situation. Remember that participants may be distrustful of the evaluation process, so try to allay their fears. Creating an atmosphere conducive to evaluation should occur with planning what to evaluate.

Evaluation objectives and topics

Inservice evaluation should address the content of the inservice, the presentation of the material (that is, the quality of work being done by the inservice facilitator), changes in the participants, and impact on the students of the participants. Impact on students is the most difficult to determine. It should not be attempted on a formal level (summative evaluation) until a certain predetermined level of classroom computer use is documented. That is, measuring the impact on students, of a computer inservice for teachers, is a complex and demanding task. It requires careful collection of baseline data (where the students are at the beginning with respect to the types of changes being fostered through the inservice).

Computer inservice is a new area. Little agreement exists among educational computer experts as to the most appropriate scope and sequence for computer related inservice. The small body of existing evaluation research is helpful in guiding the planning and design of computer inservice, but there is a word of caution. Use the research as a guide, but also tailor the inservice content to reflect the unique nature of your school district, and its long and short range computer goals. Ideally, inservice would be closely tied to carefully developed plans for instructional use of computers in schools that have been developed by the schools and districts of the educators who will participate in the inservice. The planning process is part of the needs assessment effort.

Formative evaluation occurs simultaneously with the initial needs assessment, the initial planning, and the actual conduct of the inservice. A growing body of literature on effective inservice practices and effective computer inservice practices is starting to surface (refer to Table 1). Inservice developers should use this limited research to guide their development of inservice delivery systems. Practitioners can also help the field of educational computing by making systematic studies of which techniques are the most effective and under what conditions.

Table 1 lists a number of possible areas for formative evaluation. That is, the inservice facilitator may decide to implement a number of the suggestions given in that table. Formative evaluation can help the facilitator to determine how well such a decision is being implemented.

Formative evaluation prior to and during the inservice measures how well the content met the current needs of participants. Longitudinal formative and summative evaluation determines when specific inservice programs are outdated and new ones need to be developed. It is important to remember that the goals of computer education are changing. The direction and content of computer related inservice will require careful monitoring to ensure it meets the needs of teachers, and is continually updated to reflect changes in the field.

Determining the content of a computer inservice typically begins with a needs assessment. The needs assessment process can be viewed as a special type of evaluation. The goal of needs assessment is to describe what you want the final state to be, assess the current state, and determine if their is a discrepancy between the two. If a discrepancy exists, intervention is necessary. Inservice is a common component of the intervention process.

The introduction of any innovation requires an assessment of the staff skill level with regards to the innovation, staff attitude toward the innovation, and the characteristics of the school climate that impact on implementation of an innovation.

A formal formative evaluation plan typically includes pre and post questionnaires to determine participant knowledge and attitude. This approach is quick and efficient but lacks descriptive detail, provides little evidence on participant computer skill level, and provide little insight into the problems teachers face when trying to use computers in the classroom. Combining questionnaires with informal approaches results in a richer description and may identify unanticipated problems or concerns. Informal approaches include engaging staff in informal conversations and structured interviews, attending staff meetings, and talking with administrators.

Assessment of participant initial skill level is both a delicate issue and difficult. Most inservice teachers object to the idea that they might be given tests of their knowledge and skills in an area such as instructional use of computers. This suggests that instead one should use observational techniques. These should include unobtrusive observation (walk-bys of teacher classrooms, noting who is using school computer facilities, sign out sheets for mobile computers, department requests for software and hardware) and obtrusive observation (classroom visitations). An excellent reference on unobtrusive evaluation techniques is Webb et al (1966).

Currently there is little theoretical basis for the development of effective computer related inservice. Without the development of this knowledge, staff developers will continue to reinvent the wheel every time they need to conduct computer related inservice. Documenting, through evaluation, the successes and failures can help us build a common knowledge base useful to both researchers and practitioners.

Magnitude and extent of the evaluation

The appropriate magnitude and extend of an evaluation is dependent on the magnitude of your staff development goals for integrating computers into the classroom. Small and simple goals requires smaller evaluations, while complex goals require substantial evaluation efforts. As a very rough rule of thumb, you might think of spending approximately ten percent of the inservice time, effort, and money on evaluation.

Longitudinal evaluation is a systematic way to detect permanent changes in participant behavior, the types of changes, and if the changes were the anticipated ones. Measuring changes in participant behavior enables you to assess the level of implementation that has occurred following inservice. Determining the level of implementation is important because with complex changes (such as increasing in-class computer use) staff developers frequently under estimated the time required to bring about a permanent change. Remember, evaluation of the impact on students can not be determined unless some predetermined level of in-class computer use has been achieved.

To date, most evaluation efforts have been small scale and short term. These evaluations concentrate on measuring the appropriateness of inservice content and materials, the effectiveness of the delivery system, and immediate changes in participant attitude, knowledge, or skill level occurred. This information is especially important when developing new inservice programs. However, without knowledge of the long term residual effects, it is difficult to determine what changes occurred and if they were maintained. This prevents staff developers from systematically planning what should be done next or what additional interventions are necessary before moving on.

Collecting evaluation data

One overriding concern of any evaluation plan is to not overwhelm the subjects with additional work. This is especially true when working with classroom teachers. Frequently, teachers attend inservice programs following a full day of classes and are tired. However, teachers respond positively when they feel the information provided by them is valued and will be used by the project developers.

A substantial amount of data can be gathered quite quickly if the data collection instruments are carefully designed. Keep it short and simple (KISS) is a reasonable motto. The evaluator should think carefully about the purpose of each question. How will the data be analyzed, and how will it be used?

It is also important to be aware of the attitude of the subjects you are working with. A volunteer group in general will be more respective than a coerced group. Evaluation of the the CI^3 project suggests that a volunteer group selected to participant via a competitive process will the most likely to participate in a longitudinal evaluation. (That is, the ideal situation is that the participants are volunteers, and more people volunteer than can be accommodated.)

It is highly recommended that all evaluation information be anonymous. (By this we mean that the facilitator of the inservice should not be able to connect formative and summative evaluation data collected during and after the inservice with specific individuals in the inservice.) It is a fact of life that any evaluation is stressful to people participating in it. Making all data anonymous does two things. One, it helps assure subjects their responses will not result in negative or punitive actions. Two, it creates an atmosphere where teachers are comfortable responding in an honest and frank manner to evaluation questions.

The problem of evaluation stress is compounded when computers are involved. Computer related inservice can produces high levels of stress because of the difficulty associated with integrating computers into the classroom. The combination of the normal evaluation stress and stress related to computers has the potential for creating an extremely bad situation. Reducing both sources of stress is extremely important if you want to be successful in this major change effort.

An example

In this section we will describe the development of an instrument for evaluating a computer inservice. We include the instrument that was developed and a sample of the outcomes obtained when the instrument was used with a group of secondary school science teachers who were participating in a series of inservice sessions. We will cover purposes, instrument design, file construction, statistical analysis, and interpretation. The ideas illustrated here are equally applicable in inservices in math, science, social studies, elementary education, etc.

The purpose of our evaluations in the CI^3 project were three fold: 1) *formative*, 2) *summative*, and 3) *long term residual*. Here we will concentrate on the formative and summative aspects of one workshop devoted to integrating computers into the middle and secondary school science curriculum. The same ideas can be applied to inservices aimed at other groups of educators.

Concern for the participant: Participants do not come to us to be evaluated, they come to learn. One must keep the forms and the evaluation brief. We allow about 40 minutes for the whole process during the eight two-hour inservice sessions, with 20 minutes devoted to mid course session and 20 minutes devoted to evaluation during the final session. The inservice providers were not in the room during the collection of data; the outside evaluator distributed, collected and analyzed the data.

Form Development: Many of the forms we are using to illustrate the process (a number of additional forms are given in the next chapter) were developed following observations of the sessions. The local evaluator attended the majority of the inservice sessions and had a good idea of what the content was for each session. The specifications driving the writing of the forms were to assess 1) quality of the delivery of the information, 2) interest of the material to the participant, and 3) relevance of the materials to the teaching tasks of the participants.

An evaluation instrument was developed to specifically fit the software used in the sessions. The science inservice sessions used Macintosh computers and the primary piece of software was MicroSoft Works, an integrated package. Most of the inservice participants did not have access to Macintosh computers in their schools. (This means that modifications of the instrument will be needed to fit other inservices which use different hardware and software, and focus on different subject matter.)

All evaluation instruments should end with a series of open ended questions. However, it is prudent to restrict the space allowed for writing open ended responses.

The usual method of form development involves a stage in which there is a pilot test of the form itself. In informal and semi-formal situations, this can be accomplished with a small number of people. The main ideas is to be sure that the wording is clear.

Questionnaire specifications: The instrument given in Figure 2 was used to evaluate a computer workshop designed for a mixed audience of absolutely novice and more experienced users of computers. All were middle school and high school science teachers. The main long term goal of the workshop was to increase the use of computer as a tool in the science classes taught by the participants.

The goals of the questionnaire were to evaluate the technical quality of the delivery, the specific action of some of the components, and whether the participants were able to see the major goal of the workshop. There were a few questions aimed at specific problems such as the effect of computer labs on instruction and the problems that participants may have had shifting to an unfamiliar computer. (While a number of participants had encountered the Macintosh before, relatively few had substantial experience with this machine.)

Questions 1, 7, 14, 15, 16, 18, 20, 22, and 25 are directed to the delivery of the workshop. Question 25, I would recommend this workshop session for other teachers, is particularly important. If the responses to this question was negative, then there would have been the need for extensive soul searching and a change in direction.

Questions 4, 8, 10, 11, and to some extent 9 are directed to the type of programs being presented in the first half of the workshop. In these sessions the general presentations covered using the computer and databases. This was what was being taught, it was not negotiable. Negative responses to these questions would have led to a rethinking of the delivery system, not a reemphasis on other materials.

Question 2 and 4, are directed at the general idea of the workshop. These questions were covered more thoroughly in the evaluation at the end of the workshop.

Question 23, 24, 27, and 29, were directed to some problems revolving around transferring from Apple to Macintosh computers. Question 26 was very specific because the evaluator noticed that some of the participants seemed to be having difficulty with the mechanics of typing.

In summary: We expect to ask questions focused at the content of the workshop. We expect to take a very brief look at the effectiveness of the delivery systems which include the quality of the teaching and the programs demonstrated.

Results: Figure 2 presents the evaluation instrument and sample data collected about halfway through the inservice. The relevant information to examine is the mean responses to each of the items 1-25. It is well not to overwhelm the user of the data with statistical excesses from packaged programs. The inservice facilitator may be able to modify the inservice sessions in response to major deviations from what was anticipated. Means, rounded to the nearest .5, suffice for this purpose. Of course, some inservice facilitators will want to see more detailed statistics. We have not included additional statistical data here, but the evaluator of the project provided as much detail as the facilitators desired.

Output in the form of Figure 2 contains information that is very helpful. In particular, question 3 reveals that participants see the ability to use computers more in the future as being enhanced. It is quite apparent that the overall evaluation of this workshop is good. The participants feel more confident with computer (Q1), find the material worthwhile (Q14), and see the workshop as relevant. Some of the texture of the situational setting can be found in the participants responses to the questions about availability of computers (Q21 and Q13). Those delivering the workshop should be proud of the responses to Q14, the binder and handout materials are useful; Q16, the workshop lived up to my expectations; and Q25, I would recommend this workshop to others. Responses to all these questions are near the top of the scale.

There are worries; Q2 indicates that they are not using the computer more. Q9 and Q11 indicate that more time should be spent on why databases are needed and the game of the week.

It is important to remember why this particular workshop was selected for illustration. It was the first time the science inservice was offered to a group of teachers, and it was the first time the inservice facilitator was in charge of such an extensive inservice series of sessions. Different computers were used (that is, Macintosh computers instead of the Apple 2 computers that the participants might have anticipated). The second presentation of the material (that is, a replication of the inservice series done the next year) showed that the providers made some changes that were reflected in the participants responses. The evaluator does not recommend cross groups comparisons because conditions and clients are not constant.

Science Inservice Evaluation Instrument (This is the start of Table 2)

(*Note*: This instrument was designed to require about 20 minutes to complete. The small letter "m" in the response field indicates the Mean Response of a group of science teachers who were participating in a sequence of eight two-hour computer inservices.)

Instructions: Please take about 20 minutes of your time to fill out the form. It is designed to help us assess the quality and effectiveness of the inservice, and to improve it. All responses will be confidential. Only summary statistical data and responses that cannot be used to identify specific participants will be provided to the inservice facilitator.

In the following questions, a response of 1 indicates that you strongly disagree with the statement, while a response of 5 indicates that you strongly agree with the statement. A response of 3 is neutral.

		Disagree				Agree
1.	I feel more competent with computers than I did at the start of this workshop.	1	2	3	4 m	5
2.	I am using computers more with my students than I did at the start of the workshop.	1	2 m	3	4	5
3.	As a result of this workshop, in the future I will be able to use computers more with my students.	1	2	3	4 m	5
4.	I can see ways to integrate the programs demonstrated in the workshop into my curriculum.	1	2	3	4 m	5
5.	As a result of this workshop, I have found programs not demonstrated in the workshop and integrated them into my curriculum.	1	2 m	3	4	5
6.	I have been able to interest other teachers in what we have been doing in these workshops.	1	2	3 m	4	5
7.	The sessions contain too much information to absorb comfortably.	1	2 m	3	4	5
8.	I would like to see some programs demonstrated that are directly related to science.	1	2	3	4 m	5
9.	The Game of the Week has been helpful.	1	2 m	3	4	5
10.	The sessions have helped me recognize non computerized database applications in my classroom.	1	2	3	4 m	5
11.	I feel that databases have a legitimate role in science classrooms.	1	2 m	3	4	5
12.	Time should be spent exploring practical problems like getting students to the computers.	1	2	3 m	4	5

13. The greatest block to using computers is lack of access. 1 2 3 4 5
m

14. The contents of the binder (the handouts) is worthwhile. 1 2 3 4 5
m

15. The workshop activities are relevant to my current classroom needs. 1 2 3 4 5
m

16. This workshop has lived up to my expectations. 1 2 3 4 5
m

17. I have learned a great deal about computers from other participants in the inservice. 1 2 3 4 5
m

18. We should take more time to explore the programs that we have seen in the workshops. 1 2 3 4 5
m

19. The instructors should have spent more time assessing existing computers skills in the group of participants. 1 2 3 4 5
m

20. The written materials clearly explain the software that we are using during the workshop sessions. 1 2 3 4 5
m

21. The district emphasis on computer laboratories for word processing limits access to computers at those times I might use them for science. 1 2 3 4 5
m

22. The progress of the workshop through the computer programs we have explored is slower than I would have liked. 1 2 3 4 5
m

23. Transfer (of my previous computer knowledge) from other computers to the Macintosh was relatively easy for me. 1 2 3 4 5
m

24. Learning the mechanics of using the computer is more the responsibility of the individual teacher (via working outside of the workshop) than it is of the workshop facilitators during workshop sessions. 1 2 3 4 5
m

25. I would recommend this workshop for others. 1 2 3 4 5
m

Instructions: The following four questions can be answered Yes or No. Please circle your choice.

(*Note to reader:* The percentages given are data from the same group as above.)

26. I am a reasonably competent touch typist. Yes 67% No 33%

27. I was familiar with the Macintosh computer before the start of the workshop. Yes 42% No 58%

28. The bulk of the material we have covered was familiar to me before the start of the workshop. Yes 25% No 75%

29. I was familiar with the Apple II computer or other computers before the start of the workshops. Yes 67% No 33%

Instructions: Please provide brief responses to the following questions. Use the back of the page if necessary.

30. What is the most positive aspect of the workshop?

31. What are the factors most needing improving?

32. Please write up three ideas that you think you have picked up that may be directly applicable to your classes.

33. Any other comments you would like to make would be appreciated.

Table 2: Science Inservice Evaluation Instrument

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5.2
EVALUATION FORMS

This section contains samples of a number of the evaluation forms used during the NSF project inservices.

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Principal Interview Form (Needs Assessment)	2
School Site Information Sheet	4
CI^3 Teacher Needs Assessment	5
Concerns Questionnaire	7
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Ease of Use Survey	13
Participant Log Sheet	14
Social Studies Inservice Evaluation	15

Principal Interview Form (Needs Assessment)

Name: ______________________________

School: ______________________________

Date: ______________________________

Principal interviews are conducted as part of the needs assessment. The idea is to interview the principals (or other high level school administrators) in the schools of the inservice participants. Ideally, the people being interviewed would also participate in all of the inservice sessions, or at least in a significant number of them. Research suggests that this is highly desirable if the intent is that the inservices will lead to changes in the classroom. School administrators are key educational change agents. Unless they give open and strong support to teachers working to make change in the curriculum, relatively little change is apt to occur.

One typically begins an interview by explaining its purpose and what the information will be used for. The person being interviewed should be assured that the information will be confidential. Some people doing interviewing find it desirable to use a tape recorder. If this is done, be sure to ask the interviewee if he/she minds being recorded. Since direct quotes of the answers are not needed and many people feel uncomfortable talking into a recorder, it is probably better to not make use of a recorder.

When several people are to be interviewed for the same purpose, it is helpful to have a script or a sequence of questions that all will be asked. However, feel free to deviate from the script in order to follow up on important issues.

1. What do you perceive are the most pressing needs related to the use of computers in your school? (*Note*: Presumably the interviewee knows that your orientation is toward instructional uses of computers. However, you might find that the answer provided is oriented toward administrative uses. If so, you might want to try this question again, but emphasizing instructional uses.)

2. Please describe the role and duties of the computer coordinator or computer building representative at your school. (If there is no such person, probe to find the name of the person who tends to do the most in helping the school make instructional use of computers.)

3. Please describe some of the instructional uses of computers currently occurring at your school

4. What computer equipment is available for use by students and teachers at your school? Where and/or how is it situated?

5. What training has your staff had in the use of computers?

6. What training have you had? (Describe how you use computers to do your job.)

7. Does your school have a written set of long-range plans for instructional use of computers? (If yes, can you provide me with a copy? What are some of its key goals?)

8. Does your school district have a written set of long-range plans for instructional use of computers. (If yes, can you briefly describe the plans?)

9. Are there other important things I should know about instructional use of computers in your school that would be helpful in designing and conducting inservice for your teachers?

School Site Information Sheet

(*Note*: It is often quite desirable to hold inservice sessions in the schools of the participants. This form is designed to aid in collection of information about the computer facilities available in a school that might be available for inservice sessions and/or that might be available to inservice participants for their personal use and use with students.)

Site ____________________ Contact Person ____________________

Which equipment is available? ____________________

____

When is equipment available? ____________________

____

Where is equipment available? ____________________

____

What is the procedure for organizing or obtaining equipment for use in the classroom?

____

____

What is the procedure for securing the lab? ____________________

____

What software is available? ____________________

____

____

How is it obtained? ____________________

____

Time schedule? (Obtain a copy of the school and its teachers' time schedule.)

CI^3 Teacher Needs Assessment

Name: ______________________________

School: ______________________________

(This instrument is designed to be filled out by teachers who might be interested in participating in a computer inservice. One way to make use of this instrument is to meet with the teachers in a school who have expressed some interest in an inservice. Discuss the nature of the types of inservices that might be possible. Answer their questions. Then have each person who might be interested in participating in an inservice fill out the following form. Assure the teachers that the results will be confidential.)

Instructions:

For numbers **1-5** below, please circle yes or no.

1. Have you requested that your school or department purchase any software within the last year?

   YES NO

2. Have you used the school district's software preview center within the past 12 months?

   YES NO

3. Does the integration of the computer in education change the priorities of what should be taught in the curriculum?

   YES NO

4. Do you plan to purchase a personal computer within the next 12 months?

   YES NO

5. Do you have a computer in your home?

   YES NO

   If you circled **YES**,

   (a) What brand and model is it?

   (b) How much is it used, and for what purposes?

(c) Do you bring it into the classroom? YES NO

Instructions:

For numbers **6-14** below, please write a **brief** answer.

6. List the **subject areas** in your curriculum where you think computer use is currently helping **your students**.

7. List the general types of **computer applications** you think are currently helpings **your students**.

8. List the **subject areas** in your curriculum where you think computer use is currently helping **you**.

9. List the general types of **computer applications** you think are currently helping **you**.

10. List the areas (not necessarily in your classroom) where you might like to use a computer if you could gain appropriate training and access to facilities (ie., any kind of personal use, recreation, database, gradebook, etc.).

11. List the **names** of the computer programs/packages (titles) you have ordered or requested to be ordered for educational/school use in the last year.

12. List the **names** of the top 5 computer programs/packages (titles) that you use or have used most frequently with your students.

13. (a) List the **names** of the top five computer programs/packages (titles) that you use in your role as an educator or for personal use.

(b) Indicate the **approximate number** of computer programs/packages you use with your classes? _______

(c) Indicate the **approximate number** of computer programs/packages that you use for personal use? _______

14. What kind of inservice or workshops would you like to see in the future? What characteristics and content would they have to have so that you would probably participate on a voluntary basis?

Concerns Questionnaire

Name ______________________________

Date ____________

The purpose of this questionnaire is to determine the concerns people have about future educational innovations. The items were developed from typical responses of school and college educators who ranged from having no knowledge at all about various innovations to many years experience in using them. Therefore, *a number of the items may appear to be of little relevance to you at this time*. For the completely irrelevant items, please circle "0" on the scale. Other items will represent those concerns you *do* have, in varying degrees of intensity, and should be marked higher on the scale, according to the explanation at the top of each of the following pages.

For example:

0	1	2	3	4	5	6	7
	Not true of me now		Somewhat true of me now			Very true of me now	

0 1 2 3 4 5 6 [✓ 7]	This statement is very true of me at this time. (Circle the 7. A slightly less strong response would be given by circling the 6.)
0 1 2 3 [✓ 4] 5 6 7	This statement is somewhat true of me now. (Circle the 4. A slightly weaker response would be given by circling the 3 while a slightly stronger response would be given by circling the 5.)
0 [✓ 1] 2 3 4 5 6 7	This statement is not at all true of me at this time. (Circle the 1. A slightly stronger response would be given by circling the 2.)
[✓ 0] 1 2 3 4 5 6 7	This statement seems irrelevant to me. (Circle the 0.)

Please respond to the items in terms of your present concerns, or how you feel about your involvement or potential involvement with integration of computers into instruction. We do not hold to any one definition of this innovation, so please think of it in terms of your own perception of what it involves. Since this questionnaire is used for a variety of innovations, the term computer integration never appears. However, phrases such as "the innovation," "This approach," and "the new system" all refer to computer integration. Remember to respond to each item in terms of your present concerns about your involvement or potential involvement with computer integration.

Thank you for taking time to complete this task.

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0	1	2	3	4	5	6	7
	Not true of me now		Somewhat true of me now			Very true of me now	

0 1 2 3 4 5 6 7	I am concerned about evaluating my impact on students.
0 1 2 3 4 5 6 7	I would like to revise the innovation's instructional approach.
0 1 2 3 4 5 6 7	I am completely occupied with other things.
0 1 2 3 4 5 6 7	I would like to modify our use of the innovation based on the experiences of our students.
0 1 2 3 4 5 6 7	Although I don't know about this innovation, I am concerned about things in the area.
0 1 2 3 4 5 6 7	I would like to excite my students about their part in this approach.
0 1 2 3 4 5 6 7	I am concerned about time spent working with nonacademic problems related to this innovation.
0 1 2 3 4 5 6 7	I would like to know what the use of the innovation will require in the immediate future.
0 1 2 3 4 5 6 7	I would like to coordinate my effort with others to maximize the innovation's effects.
0 1 2 3 4 5 6 7	I would like to have more information on time and energy commitments required by this innovation.
0 1 2 3 4 5 6 7	I would like to know what other faculty are doing in this area.
0 1 2 3 4 5 6 7	At this time, I am not interested in learning about this innovation.
0 1 2 3 4 5 6 7	I would like to determine how to supplement, enhance or replace the innovation.
0 1 2 3 4 5 6 7	I would like to use feedback from students to change the program.
0 1 2 3 4 5 6 7	I would like to know how my role will change when I am using the innovation.
0 1 2 3 4 5 6 7	Coordination of tasks and people is taking too much of my time.
0 1 2 3 4 5 6 7	I would like to know how this innovation is better than what we have now.

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0	1	2	3	4	5	6	7
	Not true of me now		Somewhat true of me now			Very true of me now	

0 1 2 3 4 5 6 7 I am concerned about students' attitudes toward this innovation.

0 1 2 3 4 5 6 7 I now know of some other approaches that might work better.

0 1 2 3 4 5 6 7 I don't even know what the innovation is.

0 1 2 3 4 5 6 7 I am concerned about about not having enough time to organize myself each day.

0 1 2 3 4 5 6 7 I would like to help other faculty in their use of the innovation.

0 1 2 3 4 5 6 7 I have a very limited knowledge about the innovation.

0 1 2 3 4 5 6 7 I would like to know the effects of reorganization on my professional status.

0 1 2 3 4 5 6 7 I am concerned about conflict between my interests and my responsibilities.

0 1 2 3 4 5 6 7 I am concerned about revising my use of the innovation.

0 1 2 3 4 5 6 7 I would like to develop working relationships with both our faculty and outside faculty using this innovation.

0 1 2 3 4 5 6 7 I am concerned about how the innovation affects students.

0 1 2 3 4 5 6 7 I am not concerned about this innovation.

0 1 2 3 4 5 6 7 I would like to know who will make the decisions in the new system.

0 1 2 3 4 5 6 7 I would like to discuss the possibility of using the innovation.

0 1 2 3 4 5 6 7 I would like to know what resources are available if we decide to adopt this innovation.

0 1 2 3 4 5 6 7 I am concerned about my inability to manage all the innovation requires.

0 1 2 3 4 5 6 7 I would like to know how my teaching or administration is supposed to change.

0 1 2 3 4 5 6 7 I would like to familiarize other departments or persons with the progress of this new approach.

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Demographic Self-Description

PLEASE COMPLETE THE FOLLOWING:

1. What percent of your job is:

   teaching ____% Administration ____% Other (specify)______________%

2. Do you work: full time _____ part time _____

3. Female _____ Male _____

4. Age: 20-29 ____ 30-39 ____ 40-49 ____ 50-59 ____ 60-69 ____

5. Highest degree earned:

   Associate _____ Bachelor _____ Masters _____ Doctorate _____

6. Year degree earned: _____

7. Total years teaching _____

8. Number of years at present school: _____

9. In how may schools have you held full time appointments?

   one____ two ____ three ____ four ____ five or more ____

10. How long have you been involved in computer integration, not counting this year?

    never ___ 1 year ___ 2 years ___ 3 years ___ 4 years ___ 5 years or more ___

11. In your use of computer integration, do you consider yourself to be a:

    nonuser ___ novice ___ intermediate ___ old hand ___ past user ___

12. Have you received formal training in computer integration (workshops, courses):

    yes _____ no _____

13. Are you currently in the first or second year of use of some major innovation or program other than computer integration?

    yes _____ no _____

    If yes, please describe this program briefly.

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Computer Attitudes Survey

Name: ______________________

School: ______________________

(*Note*: It is relatively common to administer an attitude scale before and after an inservice, and perhaps a third time for long term follow-up. This is done as part of the summative evaluation of an inservice. As for all collections of evaluative information, participants should be reassured that the information collected will be confidential and will not affect their grade in the inservice. Ideally, this survey form would be administered, collected, and analyzed by someone other than the inservice facilitator.)

Instructions:
Please circle the number that best describes your attitude. If you strongly agree with the statement circle 1 for strongly agree. If you strongly disagree with the statement circle 5. Circle 3 if your attitude toward the statement is neutral.

	Strongly Agree				Strongly Disagree
1. Computers can improve learning of higher order skills.	1	2	3	4	5
2. Computers will improve education.	1	2	3	4	5
3. Computers can improve drill and practice.	1	2	3	4	5
4. Computers will create jobs needing specialized training.	1	2	3	4	5
5. Computers will improve health care.	1	2	3	4	5
6. A person today cannot escape the influence of computers.	1	2	3	4	5
7. Computers will displace teachers.	1	2	3	4	5
8. Computers will dehumanize society.	1	2	3	4	5
9. Computers can teach better than teachers.	1	2	3	4	5
10. Computers are beyond the understanding of the typical person.	1	2	3	4	5
11. Computers will replace low-skill jobs.	1	2	3	4	5

Scale from *Computer Attitudes Factor Structure* developed by Bannon, Susan H., Marshall, Jon C., and Fluegal, Susan in Cognitive and affective computer attitude scales: A validity study. *Educational and Psychological Measurement*, 45, 679-681.

Sample Results from Computer Attitudes Survey

The Computer Attitudes Survey was administered to 28 participants at the beginning and end of an eight-session inservice designed to teach tool use of computers in the curriculum. The table below gives the means of their responses. The last column gives the results of a 2-tail t-test, and indicates a significant change only on the first item.

Item Number	Beginning Mean	Ending Mean	2-tail t-test $p =$
1.	1.786	1.250	.026
2.	1.857	1.929	.731
3.	1.571	1.714	.355
4.	1.407	1.500	.490
5.	2.036	1.857	.408
6.	1.357	1.429	.691
7.	4.571	4.750	.259
8.	4.179	4.250	.646
9.	4.500	4.643	.460
10.	4.357	4.714	.096
11.	3.321	3.500	.456

Ease of Use Attitude Survey

Name: ____________________

School: ____________________

(*Note*: This attitude survey form could be administered concurrently with the Computer Attitudes Survey. For many teachers, their attitude toward ease of availability and access of computer software and hardware may be a major determining factor in whether they make instructional use of computers for themselves and their students.)

Instructions:
The following activities relate to the ease of using computers and software in your curriculum and classroom. For numbers 1-7, please circle the number that **best** describes your attitude towards each activity. The scale runs from 1 (Very Difficult) to 5 (Very Easy).

Difficult	Very Easy				Very
1. Obtaining a computer and monitor for use in my class is	1	2	3	4	5
2. Obtaining the proper software is	1	2	3	4	5
3. Scheduling the use of the computer lab for my class is	1	2	3	4	5
4. Obtaining time for setting up the computer in my class is	1	2	3	4	5
5. Obtaining time for learning how to use and review new software is	1	2	3	4	5
6. Obtaining time for using the computer within the present curriculum is	1	2	3	4	5
7. Using a computer and software in my class is	1	2	3	4	5

8. The number of machines available for use in my classroom is __________

9. The number of teacher(s) who share the available machines is __________

Participant Log Sheet

(*Note*: Participants were requested to keep a daily log of their computer use and related activities during the weeks of the inservice sessions. These were turned in each week and provided the inservice facilitator with valuable formative evaluation information.)

Name ______________________________ Date ____________

Please use this form to record **all** of your computer-related activities, both at school and at home, during the week. This log sheet is not used for grading purposes. Its purpose is to provide formative evaluation information to the inservice facilitator.

Monday

Tuesday

Wednesday

Thursday

Friday

Weekend

Use back of sheet for notes, additional comments, and questions you would like to ask the inservice facilitator.

Social Studies Inservice Evaluation Form

(*Note*: A formative evaluation form of this sort can be used in almost any inservice directed toward helping participants learn to make increased and appropriate instructional use of computers in their classrooms. The sample form provided here was designed for use in an inservice for secondary school social studies teachers. With slight modification it can be used in a math, science, elementary school, etc. inservice. Participants should be assured that their answers will be kept confidential and will have no bearing on their grade in the inservice, if grades or other requirements have been established for satisfactory completion of the inservice. It is desirable that this form be administered by someone other than the inservice facilitator and that the results be compiled by someone other than the inservice facilitator. The inservice facilitator should only receive summary statistical data and participant comments that cannot be associated with specific participants. Note also that the same form could be used several times during an inservice that extended over a number of sessions.)

Name: ____________________________

School: ____________________________

We are interested in your overall evaluation of this workshop. For numbers 1 - 34, please circle the number that best describes your attitude. If you agree with the statement circle 5 for agree. If you disagree with the statement circle 1. Circle 3 if your attitude toward the statement is neutral.

		Disagree				Agree
1.	I feel more competent with computers than I did at the start of this workshop.	1	2	3	4	5
2.	My students have increased their classroom use of computers as a result of this workshop.	1	2	3	4	5
3.	Lack of student access to computers is the greatest block to my integrating computers into the curriculum.	1	2	3	4	5
4.	I feel competent integrating the software programs and activities demonstrated in the workshop into my teaching.	1	2	3	4	5
5.	I have sought out and located software programs not demonstrated in the workshop and integrated them into my curriculum.	1	2	3	4	5
6.	I have been able to interest other teachers in what we have been doing in these workshops.	1	2	3	4	5
7.	Too much information was presented during the sessions to absorb comfortably.	1	2	3	4	5
8.	I would like to see the workshop demonstrate software programs and activities more directly related to my content area.	1	2	3	4	5

		Disagree				Agree
9.	Time should be spent exploring practical problems like getting students to the computers.	1	2	3	4	5
10.	As a result of this workshop I will increase my instructional use of computers with my students.	1	2	3	4	5
11.	The contents of the participant notebook and handouts will be useful in planning and developing computer related activities for my classes.	1	2	3	4	5
12.	I have started collecting computer software disks.	1	2	3	4	5
13.	This workshop has lived up to my expectations.	1	2	3	4	5
14.	I have learned a great deal about computers from other participants in the workshop.	1	2	3	4	5
15.	More time should have been set aside for participants to explore the software programs and materials demonstrated during the workshop.	1	2	3	4	5
16.	The written materials clearly explain how to move through the programs.	1	2	3	4	5
17.	The progress of the workshop is slower than I would have liked.	1	2	3	4	5
18.	The information presented in the sessions is relevant to my classroom.	1	2	3	4	5
19.	I would recommend this workshop to other teachers.	1	2	3	4	5
20.	I am not convinced that computers will increase student achievement in my content area.	1	2	3	4	5
21.	I now talk more to other teachers about computers than I did at the start of the workshop.	1	2	3	4	5
22.	Money for computers should be shifted from other areas of the school budget.	1	2	3	4	5
23.	The instructors should have spent more time demonstrating a greater variety of software.	1	2	3	4	5
24.	The greatest block to my using computers in the classroom is my philosophical disagreement with their worth in my content area.	1	2	3	4	5
25.	The progress of the workshop is faster than I would have liked.	1	2	3	4	5

		Disagree				Agree
26.	Lack of teacher access to computers is the greatest block to my using computers.	1	2	3	4	5
27.	I would like a workshop leader to come into my classroom and demonstrate a lesson using the computer as an instructional tool.	1	2	3	4	5
28.	I feel more comfortable using computers with my students than I did at the start of the workshop.	1	2	3	4	5
29.	I am willing to have someone come into my classroom and observe me using computers with my students.	1	2	3	4	5
30.	I am more inclined to let students use computers to develop an understanding of concepts and ideas than I was at the start of the workshop.	1	2	3	4	5
31.	I would have liked time during the workshop to modify and/or develop computer activities for use in my classroom.	1	2	3	4	5
32.	I would prefer that all workshop participants be teaching the same courses and grade levels.	1	2	3	4	5
33.	I found it easy to get access to computer hardware and software between sessions to try out ideas we learned in the workshop.	1	2	3	4	5
34.	I would be more likely to use computers if there was a computer resource person I could consult with at my school.	1	2	3	4	5

For questions 35-40 circle, please circle yes if you agree with the statement and no if you disagree with the statement.

35.	I have spent more time watching others use the computers in the workshop than I have spent in using them myself.	Yes	No
36.	The goal of this workshop should be developing teacher skills in the practical use of the computer.	Yes	No
37.	I felt pressure to attend this workshop from other sources.	Yes	No
38.	I would rather spend more time with the computers and less time concerning ourselves with issues such as other resources in the school.	Yes	No

39. The goal of this workshop should be developing an understanding of how to integrate computers into my content area. Yes No

40. I have increased my understanding of how to use computers as a problem solving tool as a result of this workshop. Yes No

For numbers 41-48 please circle the number the best describes your attitude toward each of the software programs listed. If you think the program was excellent circle 5 for excellent. If you think the program was poor circle 1. Circle 3 if your attitude toward the program is neutral. Please do not refer to your handouts or notebook; we are interested in how you remember these software programs.

		Poor				Excellent
41.	United States Database	1	2	3	4	5
42.	North American Database	1	2	3	4	5
43.	President Elect	1	2	3	4	5
44.	The Other Side	1	2	3	4	5
45.	U.S. History	1	2	3	4	5
46.	Easy Graph	1	2	3	4	5
47.	MECC Graph	1	2	3	4	5
48.	Bank Street File	1	2	3	4	5

Please write brief answers to the following questions.

1. Has the workshop been relevant to your needs?

2. Has the workshop been organized in a way that facilitated learning? If not, how can we improve it?

3. Please write a short description (2 or 3 sentences) of what you perceive as the purpose of the workshop.

4. Identify the most positive aspect(s) of the workshop?

5. Please describe two or three ideas demonstrated during the workshop that are directly applicable to your classes.

6. What can we do to improve this workshop and others like it?

7. Please feel free to make any general comments about the in-service.

5.3
LONG TERM FOLLOWUP EVALUATION

As indicated in Section 5.1, relatively few inservice projects conduct meaningful long term followup evaluation to determine possible effects of the inservice. The NSF project conducted quite a bit of long term followup evaluation. Most of this research was conducted by two graduate students who were employed by the project and conducted the evaluations as part of their Ph.D. dissertation research. The references to their Ph.D. dissertations are given below. Each of these dissertations is available for $20 from the International Council for Computers in Education, 1787 Agate Street, Eugene, Oregon 97403.

Hanfling, Seymour Samuel (December 1986). A formative evaluation of elementary and secondary staff development inservices on integrating computer innovations into the curriculum. Ph.D Dissertation, University of Oregon.

Johnson, Vivian Patricia (August 1988). An exploratory case study describing the long-term residual effect of the computer-integrated instruction inservice (CI^3 project). Ph.D. Dissertation, University of Oregon.

The following pages contain some of the instrumentation that was used in the long term evaluation. Much more detail is provided in the Ph.D. dissertations. Readers interested in the details of such long term evaluation are well advised to begin by reading Vivian Johnson's dissertation.

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CI^3 Project Long Term Assessment	9

CI^3 Inservice Participant Focused Interview (Long Form)

Site: ______________________ Date: __________________

Subject: ______________________ Researcher: ______________

Introduction

Purpose	This interview is part of the CI^3 inservice follow-up. The interview is a major source of data to help us determine the residual effect of the inservice you completed.
Topics to be covered	Interview questions will briefly cover the following topics: your teaching experience, your experience with computers, features of the inservice, your attitude and expectations about using computers in education, and how completing the inservice affected you. If there is time available at the end of the interview, please feel free to go back and provide more detail on specific questions.
Ethics	I would like to tape record this interview only for the purpose of validating the accuracy of my questions. The taped interview will be heard by only myself and (list and other names and explain why they may also listen to the recording). Your name will never be mentioned, nor will any particular response be connected to you. In addition, you may turn the tape recorded off at any time.
Concerns of respondent	Do you have any questions or concerns before I begin?

Experience

(Time allocation 5 min)

Teaching	How long have you been teaching (brief)?
Computers	Briefly describe your experience with computers.
	If experienced, what brands of computers do you feel ***comfortable*** using?

___ Apple

___ Atari

___ Commodore (PET)

___ Macintosh

___ IBM

___ Radio Shack

___ Commodore C-64

___ Other (Note Brand)

Inservice Features

(Time Allocation 5-7 min.)

Content	What did you perceive as the ***subject*** of the inservice you completed?
Positive features	What were the ***features*** that made the inservice work best for you? Examples?
	(As a backup, show list of inservice features and ask: Do you remember any of these features?)
Limitations	What ***features*** of the inservice ***limited*** its success?
	(As a backup, show list of features and ask: Others say these features are the most important, what would you add or delete? Did your inservice have these?)

Changes over time	Would your answers have been different just after you finished the inservice?
Attitudes and Expectations	(Time allocation 10 min.)
Computers in education	What do you think we should be doing with computers in education?

Probe to elicit teachers' perceptions in the following areas: appropriate uses of computers

____ enrichment ____ remediation

____ regular instruction

If time permits suggest teachers describe some specific examples of appropriate uses.

Teaching	What would you like to be doing with computers in your own classroom?
Effect on students	What effect will classroom use of computers have on your students? How will they respond? What will they learn?
Reason for inservice	Why did you sign up for the inservice? Was it voluntary? __ yes __ no
Anticipated Outcomes	What did you hope to learn? What did you hope to be able to do?
Outcomes	(Time allocation 15 min.)
Expectations	Did you learn what you hoped to learn? Why? Why not?
Knowledge and Skills	Describe what you learned? What facts and skills?
Teaching	Did the inservice affect the way you teach? Either how you teach or what you teach?
Students	Name the computer applications that you feel are the most beneficial to your students? (Provide only word processing as an example of a computer application.)

	Have you seen changes in your students since using computers in the class? (Possible examples: student attitude towards school, towards learning, towards subject matter.)
Plans	What do you plan to be doing with computers in the future?
Problems	What factors influence your choice to use or not use computers in your classroom. (If participants have difficulty answering this questions - suggest they think about the following: access to computers, time issues, support from school administration, etc.
	What problems have you had trying to use computers that the inservice did not prepare you to solve?
Changes in inservice	How would you change the inservice (Omit if time becomes a problem)
Final Instructions	We are at the end of the interview, is there anything else you would like to mention or a question you wish to go back to. **Please thank the individual for their time and input and tell them they have been very helpful.**

CI^3 Inservice Participant Focused Interview
(Short Form)

Name: ______________________

School: ______________________

Date: ______________________

Instructions:

Instruct the participant to answer the following questions as briefly as possible. (*Note*: Use the same confidentiality discussion as is given with the Long Form.)

1. Describe the purpose of the CI^3 computer workshop.

2. State why you participated in the CI^3 computer workshop.

3. List three changes, in you as an individual or teacher, that can be attributed to your participation in the CI^3 sessions.

    a)

    b)

    c)

4. Identify the three most important experiences that occurred during the training.

   a)

   b)

   c)

5. List the **subject areas**, identified in the training, where computer use benefits **your students**.

6. List the **computer applications,** identified in training, that benefit **your students**.

7. List the **subject areas,** discussed in training, where you think computer use **benefits you**.

8. List the **computer applications,** utilized in training, that **benefit you**.

9. Do you feel you know enough about computers to make **effective** use of them in **your** teaching?

10. How has the **non-computer content** of what you teach been affected by your increasing computer knowledge?

CI^3 Project Long Term Assessment

Name: ____________________

School: __________________

Instructions for Part 1:
For numbers **1-9** below, please circle yes or no.

1. Do you still have, use, or reference the **computer workshop** handouts/materials?

   YES NO

2. Prior to the computer workshop, was there an in-school computer interest or support group at your school?

   YES NO

3. Following the completion of the workshops, has a computer interest or support group been formed?

   YES NO

4. Have you requested that your school or department purchase any software within the last year?

   YES NO

5. Do you use the school district's software preview center?

   YES NO

6. Do you have a computer in your home?

   YES NO

   If you circled **YES**,

   (a) What brand and model is it?

   (b) Do you bring it into the classroom?

   YES NO

7. Do you plan to purchase a personal computer within the next 12 months?

   YES NO

8. Does the integration of the computer in education change the priorities of what should be taught in the curriculum?

   YES NO

9. Do you feel that you know enough about computers to make effective use of them in your teaching?

YES NO

10. (a) List the **names** of the top five computer programs/packages that you use either in your role as an educator or for personal use.

(b) Indicate the **approximate number** of computer programs/packages you use with your classes? ______

(c) Indicate the **approximate number** of computer programs/packages that are for your personal use? ______

11. List the **names** of the top five computer programs/packages (titles) that you use or have used most frequently with your students.

Instructions for Part 2:
Please answer each of the following questions with a checkmark (√) .

1. Before the inservice sessions, how involved were you in integrating computers into your curriculum?
   ___ none ___ slightly ___ somewhat ___ very

2. Since the inservice training, have you increased your involvement in the integration of computers into the curriculum?
   ___ none ___ slightly ___ moderately ___ much

3. Before the training, were you part of a local computer support group?
   ___ Yes ___ No

4. Since the training, have you been involved in starting a local computer support group or become a member of one?
   ___ Yes ___ No

5. Since the inservice sessions, have you increased you communications with others about integrating computers into the curriculum?
   ___ Yes ___ No

   If you checked "yes" to question number 5, please indicate the approximate number of people you have communicated with in each of the following categories:

Approximate Number of People	Categories
________	Shared information with people unaware of how to integrate computers into the curriculum.
________	Exchanged information with people already involved with integrating computers into the curriculum.
________	Contacted other inservice session participants.

6. Have you used any of the materials you received at the inservice sessions?
   ___ Yes ___ No

   If you checked "yes," how useful did you generally find the materials to be? Please check one.
   ___ Useless ___ Hardly useful ___ Somewhat useful ___ Very useful

7. Do you think the type of training you received helps to promote computer integration into the curriculum? ___ Yes ___ No

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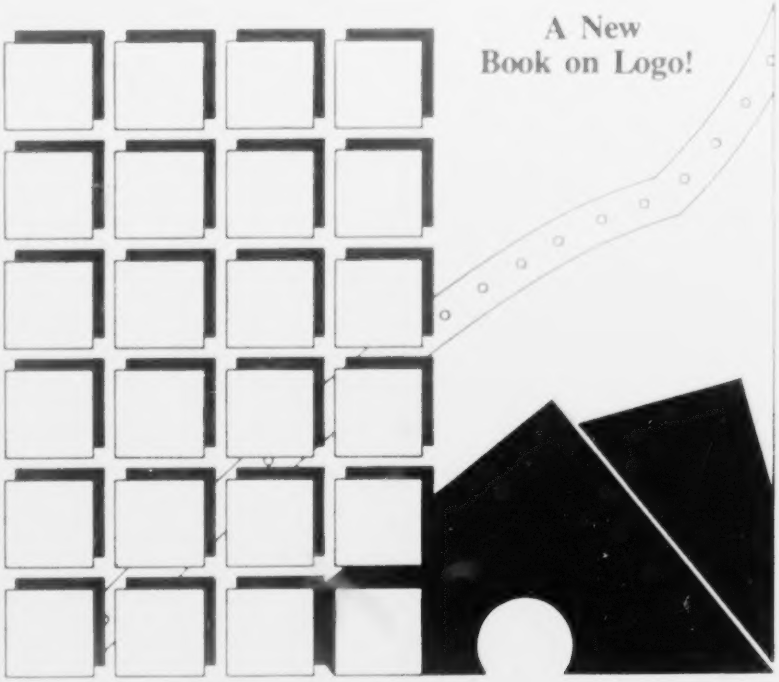

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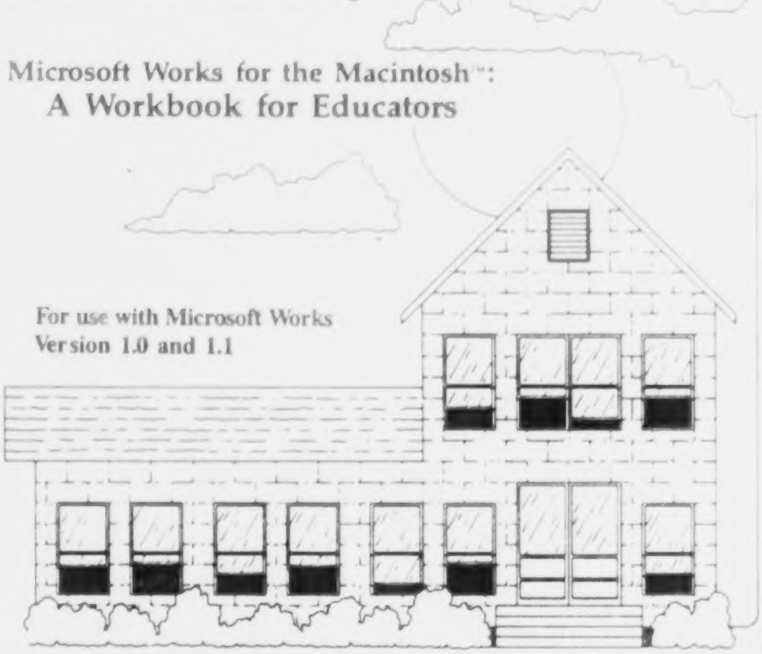

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The International Council for Computers in Education was founded by Dr. David Moursund in 1979 as an organization that would foster appropriate instructional use of computers throughout the world.

Today ICCE is the largest professional organization for computer educators at the precollege level. It is [illegible] supported by 12,000 individual members and more than 50 organizations of computer-using educators worldwide. These organizations are statewide or region-wide in scope, averaging 500 members each. Approximately 84% of ICCE's individual membership is in the United States, 12% is in Canada, and the remainder is scattered around the globe.

About The Computing Teacher

ICCE publishes The Computing Teacher [illegible]

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